

**Volume VIII of IX (Appx59111-Appx59860)**  
**No. 2024-1285**

---

---

**UNITED STATES COURT OF APPEALS**  
**FOR THE FEDERAL CIRCUIT**

---

APPLE INC.,

*Appellant,*

v.

INTERNATIONAL TRADE COMMISSION,

*Appellee,*

MASIMO CORPORATION, CERCACOR LABORATORIES, INC.,

*Intervenors,*

---

On Appeal from the United States International Trade Commission  
in Investigation No. 337-TA-1276

---

**NON-CONFIDENTIAL JOINT APPENDIX**

---

RONALD A. TRAUD  
Attorney Advisor  
Office of the General Counsel  
U.S. International Trade Commission  
500 E Street, SW  
Washington, DC 20436  
Telephone (202) 205-3427

*Attorney for Appellee International Trade  
Commission*

JOSEPH R. RE  
KNOBBE, MARTENS, OLSON & BEAR, LLP  
2040 Main Street, 14th Floor  
Irvine, CA 92614  
(949) 760-0404

*Attorney for Intervenors  
Masimo Corporation and  
Cercacor Laboratories, Inc.*

MARK D. SELWYN  
WILMER CUTLER PICKERING  
HALE AND DORR LLP  
2600 El Camino Real, Suite 400  
Palo Alto, CA 94306  
(650) 858-6000  
*Attorney for Appellant Apple Inc.*

August 7, 2024     *ADDITIONAL COUNSEL LISTED ON INSIDE COVER*

---

---

DOMINIC L. BIANCHI  
General Counsel  
Office of the General Counsel  
U.S. International Trade Commission  
500 E Street, SW  
Washington, DC 20436  
Telephone (202) 205-3061

WAYNE W. HERRINGTON  
Assistant General Counsel  
Office of the General Counsel  
U.S. International Trade Commission  
500 E Street, SW  
Washington, DC 20436  
Telephone (202) 205-3090

*Attorneys for Appellee  
International Trade Commission*

STEPHEN C. JENSEN  
SHEILA N. SWAROOP  
BRIAN C. CLAASSEN  
KNOBBE, MARTENS, OLSON & BEAR, LLP  
2040 Main Street, 14th Floor  
Irvine, CA 92614  
(949) 760-0404

JONATHAN E. BACHAND  
KNOBBE, MARTENS, OLSON & BEAR,  
LLP  
1717 Pennsylvania Avenue N.W.  
Suite 900  
Washington, DC 20006  
(202) 640-6400

*Attorneys for Intervenor  
Masimo Corporation and  
Cercacor Laboratories, Inc.*

JOSEPH J. MUELLER  
SARAH R. FRAZIER  
WILMER CUTLER PICKERING  
HALE AND DORR LLP  
60 State Street  
Boston, MA 02109  
(617) 526-6000

THOMAS G. SPRANKLING  
WILMER CUTLER PICKERING  
HALE AND DORR LLP  
2600 El Camino Real, Suite 400  
Palo Alto, CA 94306  
(650) 858-6000

DEREK GOSMA  
WILMER CUTLER PICKERING  
HALE AND DORR LLP  
350 S. Grand Avenue, Suite 2400  
Los Angeles, CA 90071  
(213) 443-5300

DAVID P. YIN  
WILMER CUTLER PICKERING  
HALE AND DORR LLP  
2100 Pennsylvania Avenue NW  
Washington DC 20037  
(202) 663-6000

*Attorneys for Appellant Apple Inc*

## TABLE OF CONTENTS

### Page(s)

### VOLUME I of IX

Order No. 1, Protective Order, EDIS Doc ID 749877 (Aug. 18, 2021)

Order No. 13, Granting Joint Motion to Amend the Protective Order to Add Provisions regarding Production and Review of Source Code, EDIS Doc ID 760100 (Jan. 10, 2022)

### ORDERS AND OPINIONS

Final Initial Determination on Violation of Section 337, EDIS Doc ID 789795 (Feb. 7, 2023) **[PUBLIC VERSION]** Appx1-Appx343

Limited Exclusion Order, EDIS Doc ID 807002 (Oct. 26, 2023) Appx344-Appx347

Cease and Desist Order, EDIS Doc ID 807049 (Oct. 26, 2023) Appx348-Appx355

Commission's Final Determination Finding a Violation of Section 337; Issuance of a Limited Exclusion Order and a Cease and Desist Order; Termination of the Investigation, EDIS Doc ID 807001 (Oct. 26, 2023) Appx356-Appx359

Commission Opinion, EDIS Doc ID 808521 (Nov. 14, 2023) **[PUBLIC VERSION]** Appx360-Appx484

### PATENTS-IN-SUIT

U.S. Patent No. 10,912,501 (JX-001) Appx485-Appx596

### VOLUME II of IX

### PATENTS-IN-SUIT (continued)

U.S. Patent No. 10,912,502 (JX-002) Appx597-Appx706

U.S. Patent No. 10,945,648 (JX-003)

Appx707-  
Appx817

### **CERTIFIED LIST**

Certified List for Investigation No. 337-TA-1276

Appx818-  
Appx879

### **FILINGS, ORDERS, & TRANSCRIPTS IN ITC PROCEEDINGS**

Public Complaint and Exhibits, EDIS Doc ID 745713 (June 30, 2021)

Appx1001-  
Appx2346

Complaint, Confidential Exhibits to the Public Complaint, EDIS Doc ID 745713 (June 30, 2021) **[PUBLIC VERSION]**

Appx2347-  
Appx2954

First Amended Complaint, EDIS Doc ID 746186 (July 7, 2021) **[PUBLIC VERSION]**

Appx3696-  
Appx3739

Response/Submission to ALJ Order, Response of Apple Inc. to First Amended Complaint and Notice of Investigation, EDIS Doc ID 751134 (Sept. 7, 2021) **[FILED UNDER SEAL]**

Appx4570-  
Appx5233

Order No. 4 Issuing Replacement Ground Rules, EDIS Doc ID 752396 (Sept. 22, 2021)

Appx5234-  
Appx5275

Initial Determination Extending Target Date by One Month; Rescheduling Hearing Dates; Ordering Submission of Revised Proposed Procedural Schedule, EDIS Doc ID 752398 (Sept. 22, 2021)

Appx5276-  
Appx5317

Respondent Apple Inc.'s Motion for Sanctions, and Exhibits, EDIS Doc ID 760270 (Jan. 11, 2021) **[PUBLIC VERSION]**

Appx6701-  
Appx7541

Transcript of Tutorial and Markman Hearing, EDIS Doc ID 763489 (Feb. 17, 2022)

Appx10077-  
Appx10082

Initial Determination Granting Complainants' Unopposed Motion for Partial Withdrawal of Certain Claims, EDIS Doc ID 766184 (Mar. 23, 2022)

Appx12242-  
Appx12244



Amended Response of Apple Inc. to First Amended Complaint and Notice of Investigation, EDIS Doc ID 766784 (Mar. 28, 2022) <b>[FILED UNDER SEAL]</b>	Appx13047- Appx14121
Order No. 31 Denying Respondent's Motion for Sanctions, EDIS Doc ID 771337 (Mar. 23, 2022) <b>[PUBLIC VERSION]</b>	Appx14128- Appx14141
Respondent Apple Inc.'s Corrected Pre-Hearing Brief, EDIS Doc ID 771819 (May 27, 2022) <b>[PUBLIC VERSION]</b>	Appx16998- Appx17261
Initial Determination Granting Complainants' Second Unopposed Motion for Partial Termination by Withdrawal of Certain Claims, EDIS Doc ID 771234 (May 20, 2022)	Appx17262- Appx17264
Complainants' Initial Post-Hearing Brief and Appendix, EDIS Doc ID 775168 (July 12, 2022) <b>[PUBLIC VERSION]</b>	Appx21088- Appx21467
Respondent Apple Inc.'s Post-Hearing Brief, EDIS Doc ID 775269 (July 13, 2022) <b>[PUBLIC VERSION]</b>	Appx21471- Appx21776
Complainants' Reply Post-Hearing Brief, EDIS Doc ID 776163 (July 25, 2022) <b>[PUBLIC VERSION]</b>	Appx21789- Appx22005
Respondent Apple Inc.'s Reply Post-Hearing Brief, EDIS Doc ID 776166 (July 25, 2022) <b>[PUBLIC VERSION]</b>	Appx22006- Appx22196
Complainants' Corrected Initial Post-Hearing Brief, EDIS Doc ID 778396 (Aug. 22, 2022) <b>[PUBLIC VERSION]</b>	Appx22217- Appx22596
Respondent Apple Inc.'s Second Corrected Post-Hearing Brief, EDIS Doc ID 780239 (Sept. 15, 2022) <b>[PUBLIC VERSION]</b>	Appx22612- Appx22923
Respondent Apple Inc.'s Corrected Post- Hearing Reply Brief, EDIS Doc ID 776462 (July 28, 2022) <b>[PUBLIC VERSION]</b>	Appx22924- Appx23114

### VOLUME III of IX

#### FILINGS, ORDERS, & TRANSCRIPTS IN ITC PROCEEDINGS (continued)

Final Initial Determination on Violation of Section 337, EDIS Doc ID 787648 (Jan. 10, 2023)	Appx23131- Appx23473
---	-------------------------

Complainants' Petition for Review of the Final Initial Determination, EDIS Doc ID 789339 (Feb. 3, 2023) <b>[PUBLIC VERSION]</b>	Appx23481- Appx23584
Complainants' Summary of Petition for Review of the Final Initial Determination on Violation of Section 337, EDIS Doc ID 789340 (Feb. 3, 2023) <b>[PUBLIC VERSION]</b>	Appx23585- Appx23597
Respondent Apple Inc.'s Petition for Review of the Initial Determination, EDIS Doc ID 789331 (Feb. 2, 2023) <b>[PUBLIC VERSION]</b>	Appx23598- Appx23717
Comments from Dr. Adam Waddell, EDIS Doc ID 789029 (Jan. 31, 2023)	Appx23751
Complainants' Response to Apple Inc.'s Petition for Review of the Final Initial Determination, EDIS Doc ID 790113 (Feb. 10, 2023) <b>[PUBLIC VERSION]</b>	Appx23752- Appx24048
Respondent Apple Inc.'s Response to Complainants' Petition for Review, EDIS Doc ID 790123 (Feb. 13, 2023) <b>[PUBLIC VERSION]</b>	Appx24062- Appx24166
Public Interest Statement Points supporting Masimo, filed by Christopher McCarthy, EDIS Doc ID 789080 (Feb. 1, 2023)	Appx24192- Appx24193
Support for the Apple Watch for Use in Tracking Physiologic Features in Medical Patients, filed by Russell Bowler of National Jewish Health, EDIS Doc ID 790602 (Feb. 17, 2023)	Appx24196
Letter in Support of Apple Watch, filed by Stephen Ruoss of Stanford University Medical Center, EDIS Doc ID 791060 (Feb. 21, 2023)	Appx24200- Appx24201
Public Interest Comments of David Albert, filed by David Albert of AliveCor, Inc., EDIS Doc ID 790883 (Feb. 22, 2023)	Appx24202- Appx24203
Public Interest Statement of Kevin R. Ward, filed by Kevin R. Ward of University of Michigan Medicine, EDIS Doc ID 790884 (Feb. 22, 2023)	Appx24204- Appx24206

Public Interest Statement of Non-Party Peter Pronovost, MD, filed by Peter Pronovost of University Hospitals, EDIS Doc ID 791162 (Feb. 27, 2023)	Appx24243- Appx24248
Public Interest Statement of Non-Party of Medical Device Manufacturers Association MDMA, EDIS Doc ID 791167 (Feb. 27, 2023)	Appx24254- Appx24259
Public Interest Statement of Non-Party Patient Safety Movement Foundation, EDIS Doc ID 791175 (Feb. 27, 2023)	Appx24260- Appx24265
Public Interest Statement of Non-Party Bobby Yazdani, filed by Bobby Yazdani of Cota Capital, EDIS Doc ID 791177 (Feb. 27, 2023)	Appx24266- Appx24271
Public Interest Statement of Non-Party Mitchell Goldstein, MD, filed by Mitchell Goldstein of Loma Linda University School of Medicine, EDIS Doc ID 791179 (Feb. 27, 2023)	Appx24272- Appx24277
Statement of Non-Party American Heart Association on the Public Interest of the Recommended Remedial Orders but Not in Support of Any Party, EDIS Doc ID 791476 (Mar. 1, 2023)	Appx24278- Appx24286
Public Interest Statement of Richard Milani, EDIS Doc ID 791665 (Mar. 1, 2023)	Appx24287- Appx24293
Commission Determination to Review in Part a Final Initial Determination; Request for Written Submissions on the Issues under Review and on Remedy, the Public Interest, and Bonding, EDIS Doc ID 796515 (May 15, 2023)	Appx24312- Appx24318
Complainants' Submission in Response to the Commission's May 15, 2023 Notice of Commission Determination to Review in Part, and Appendices, EDIS Doc ID 798775 (June 15, 2023) <b>[PUBLIC VERSION]</b>	Appx24319- Appx25229
Respondent Apple Inc.'s Response to the Commission's Notice to Review in Part a Final Initial Determination and Request for Written Submissions, EDIS Doc ID 798756 (June 15, 2023) <b>[PUBLIC VERSION]</b>	Appx25235- Appx25550

Correspondence, Notice of Denial of Respondent Apple Inc.'s Requests for Rehearing of Decisions Denying Institution of Inter Partes Review for U.S. Patent No. 10,945,648, EDIS Doc ID 799260 (June 26, 2023)	Appx27002- Appx27025
---	-------------------------

Order Denying Respondent's Motion to Stay Remedial Orders Pending Appeal and/or in Light of Potential Government Shutdown, EDIS Doc ID 810738 (Dec. 20, 2023)	Appx27225- Appx27229
---	-------------------------

Commission Opinion Denying Respondent's Motion to Stay the Remedial Orders, EDIS Doc ID 811278 (Jan. 3, 2023) <b>[PUBLIC VERSION]</b>	Appx27230- Appx27244
---	-------------------------

## **VOLUME IV of IX**

### **HEARING TRANSCRIPTS**

Revised and Corrected Hearing Transcript, Day 1 (pages 1-282), EDIS Doc ID 775090, 775091 (June 6, 2022) <b>[FILED UNDER SEAL IN PART]</b>	Appx40093- Appx40375
--	-------------------------

Hearing Transcript, Day 2 (pages 283-596), EDIS Doc ID 772773, 772774 (June 7, 2022) <b>[FILED UNDER SEAL IN PART]</b>	Appx40376- Appx40690
--	-------------------------

Revised and Corrected Hearing Transcript, Day 3 (pages 597-861), EDIS Doc ID 775095, 775096 (June 8, 2022) <b>[FILED UNDER SEAL IN PART]</b>	Appx40691- Appx40956
--	-------------------------

Hearing Transcript, Day 4 (pages 862-1167), EDIS Doc ID 772835, 772836 (June 9, 2022) <b>[FILED UNDER SEAL IN PART]</b>	Appx40957- Appx41263
---	-------------------------

Revised and Corrected Hearing Transcript, Day 5 (pages 1168-1459), EDIS Doc ID, 779613, 779614 (June 10, 2022) <b>[FILED UNDER SEAL IN PART]</b>	Appx41264- Appx41556
--	-------------------------

## COMPLAINANTS' ADMITTED TRIAL EXHIBITS

CX-0010 - Screen capture of Apple website: How to use the Blood Oxygen app on Apple Watch Series 6 or Series 7	Appx50028- Appx50033
CX-0103 - U.S. Patent Application Publication 2021/0093237	Appx51380- Appx51414
CX-0118 - U.S. Patent No. 10,687,718 B2	Appx51623- Appx51686
CX-0137 - U.S. Patent Application Publication U.S. 2010/0030040 A1	Appx51811- Appx51898
CX-0177C - Apple Presentation re Development of Blood Oxygen Feature <b>[SEALED]</b>	Appx51900- Appx51924
CX-0242 - Apple Press Release, "Apple Watch Series 6 delivers breakthrough wellness and fitness capabilities," 9/15/2020"	Appx52501- Appx52514
CX-0279C - Deposition Designations: 2022-02-22 Rowe, Robert <b>[SEALED]</b>	Appx52602- Appx52608
CX-0281C - Deposition Designations: 2022-02-17 Block, Ueyn <b>[SEALED]</b>	Appx52609- Appx52680
CX-0289C - Deposition Designations: 2022-02-10 Mannheimer, Paul <b>[SEALED]</b>	Appx52791- Appx52843
CX-0295C - Deposition Designations: 2022-02-11 Shui, Tao <b>[SEALED]</b>	Appx52911- Appx52941
CX-0299C - Deposition Designations: 2022-02-18 Waydo, Stephen <b>[SEALED]</b>	Appx52980- Appx53023
CX-0364C - 2020 Masimo Watch Presentation <b>[SEALED]</b>	Appx53070- Appx53095
CX-0378C - Masimo Presentation, Masimo Watch Algorithms/Sensor Document, 10/6/2020 <b>[SEALED]</b>	Appx53107- Appx53151

**VOLUME V of IX**

**COMPLAINANTS' ADMITTED TRIAL EXHIBITS**

CX-0389C - CPX-58 Sensor Circuit Board Drawing <b>[SEALED]</b>	Appx53222- Appx53225
CX-0390C - Sensor Circuit Board Drawing <b>[SEALED]</b>	Appx53226- Appx53229
CX-0392C - Masimo Watch Instrument Board Schematic <b>[SEALED]</b>	Appx53230- Appx53234
CX-0433C - Masimo Presentation, Masimo Watch <b>[SEALED]</b>	Appx53236- Appx53248
CX-0473C - CPX-52 Sensor Circuit Board Drawing <b>[SEALED]</b>	Appx53249- Appx53252
CX-0494C - Clinical Study Test Results <b>[SEALED]</b>	Appx53256- Appx53361
CX-0536C - CPX-58 Sensor Circuit Board Drawing <b>[SEALED]</b>	Appx53362- Appx53365
CX-0617C - Jan. 13, 2021 First Amendment to Design Services Agreement <b>[SEALED]</b>	Appx53459- Appx53461
CX-0623C - Watch Clinical Expenditures Spreadsheet - Appendix D to 3-4-22 Expert Report of Daniel McGavock <b>[SEALED]</b>	Appx53491
CX-0624C - Watch Corporate Expenditures Spreadsheet - Appendix C to 3-4-22 Expert Report of Daniel McGavock <b>[SEALED]</b>	Appx53492
CX-0632C - Watch Sourcing, IT, and Recruiting Expenditures Spreadsheet - Appendix F to 3-4-22 Expert Report of Daniel McGavock <b>[SEALED]</b>	Appx53497
CX-0635C - Masimo Watch R&D Expenditures Spreadsheet - Appendix B to 3-4-22 Expert Report of Daniel McGavock <b>[SEALED]</b>	Appx53499

CX-0640C - Masimo Watch R&D Expenditures Spreadsheet - Appendix M to 3-4-22 Expert Report of Daniel McGavock <b>[SEALED]</b>	Appx53503
CX-0648C - Watch Headcount Spreadsheet - Appendix S to 3-4-22 Expert Report of Daniel McGavock <b>[SEALED]</b>	Appx53506
CX-0701C - CPX-52 Sensor Circuit Board Schematic (copy produced earlier at MASITC_00526571) <b>[SEALED]</b>	Appx53813- Appx53818
CX-0704C - Circuit Board Schematic (copy produced earlier at MASITC_00966488, CX-530C)	Appx53819
CX-0705C - Sensor Circuit Board Schematic (copy produced earlier at MASITC_00584761) <b>[SEALED]</b>	Appx53820- Appx53826
CX-0709C - Instrument Board Drawing (copy produced earlier at MASITC_00974668) <b>[SEALED]</b>	Appx53827- Appx53831
CX-0710C - CPX-58 Sensor Circuit Board Schematic (copy produced earlier at MASITC_00584754) <b>[SEALED]</b>	Appx53832- Appx53838
CX-0783C - Masimo Market Strategy Presentation <b>[SEALED]</b>	Appx53927- Appx53941
CX-0835C - Photographs of Masimo Facilities <b>[SEALED]</b>	Appx54064- Appx54226
CX-0836C - Photographs of Demonstrations of Masimo Physicals <b>[SEALED]</b>	Appx54227- Appx54245
CX-1038C - Collection of Images from Apple's Inspection of Masimo Physicals, Oct. 20, 2021 <b>[SEALED]</b>	Appx54246- Appx54256
CX-1058C - Collection of Images from Apple's Inspection of Masimo Physicals, Nov. 10, 2021 <b>[SEALED]</b>	Appx54257- Appx55228
CX-1062C - Collection of Images from Apple's Inspection of Masimo Physicals, Nov. 10, 2021 <b>[SEALED]</b>	Appx55229- Appx55354
CX-1111C - Screenshots from MASITC_00618013 <b>[SEALED]</b>	Appx55359- Appx55367



CX-1124C - Screenshots from MASITC\_00971267 **[SEALED]** Appx55368-  
Appx55376

**VOLUME VI of IX**

**COMPLAINANTS' ADMITTED TRIAL EXHIBITS (continued)**

CX-1128C - Screenshots from MASITC\_00976047 **[SEALED]** Appx55385-  
Appx55388

CX-1129C - Screenshots from MASITC\_00976130 **[SEALED]** Appx55389-  
Appx55390

CX-1132C - Screenshots from MASITC\_01060793 **[SEALED]** Appx55391-  
Appx55393

CX-1137C - Screenshots from MASITC\_01060827 **[SEALED]** Appx55394-  
Appx55399

CX-1370 - Masimo Annual Report, 2014 Appx56006-  
Appx56085

CX-1482C - Cercacor Product Pitch, Sept. 14, 2016 **[SEALED]** Appx57317-  
Appx57324

CX-1493C - Cercacor Presentation, Engineering Update, Feb. 28, 2018 **[SEALED]** Appx57394-  
Appx57409

CX-1511C - Email from Masimo Team re iSpO2 (1/3/2013) **[SEALED]** Appx57410-  
Appx57412

CX-1608 - Complaint Exhibit 37, Apple Watch Series 6 review - Minute Improvements Appx57596-  
Appx57614

CX-1612C - Cross-Licensing Agreement January 1, 2007 **[SEALED]** Appx57615-  
Appx57656

CX-1616 - Fowler, Geoffrey, "The new Apple Watch says my lungs may be sick. Or perfect. It can't decide." Washington Post, September 23, 2020 Appx57659-  
Appx57664

CX-1621 - Prosecution History of U.S. Patent App. No. 12/534,827 Appx57665-  
Appx58278



CX-1622 - Prosecution History of U.S. Patent App. No. 12/829,352 (Appx58279-Appx58360)	Appx58279-Appx59360
--	---------------------

**VOLUME VII of IX**

**COMPLAINANTS' ADMITTED TRIAL EXHIBITS (continued)**

CX-1622 - Prosecution History of U.S. Patent App. No. 12/829,352, continued (Appx58361-Appx59110)	Appx58279-Appx59360
---	---------------------

**VOLUME VIII of IX**

**COMPLAINANTS' ADMITTED TRIAL EXHIBITS (continued)**

CX-1622 - Prosecution History of U.S. Patent App. No. 12/829,352, continued (Appx59111-Appx59360)	Appx58279-Appx59360
---	---------------------

CX-1623 - Prosecution History of U.S. Patent App. No. 14/981,290 (Appx59361-Appx59860)	Appx59361-Appx60003
--	---------------------

**VOLUME IX of IX**

**COMPLAINANTS' ADMITTED TRIAL EXHIBITS (continued)**

CX-1623 - Prosecution History of U.S. Patent App. No. 14/981,290, continued (Appx59861-Appx60003)	Appx59361-Appx60003
---	---------------------

CX-1634C - Drawings, Photographs, or Other Visual Representations of Masimo's Confidential Domestic Industry Product <b>[SEALED]</b>	Appx60136-Appx60153
--	---------------------

CX-1638C - Masimo Presentation, Engineering Update, 2021 Q1 (Al-Ali Dep. Ex. 9) <b>[SEALED]</b>	Appx60184-Appx60212
---	---------------------

CX-1802C - Apple Presentation <b>[SEALED]</b>	Appx60425-Appx60431
---	---------------------

CX-1805C - Email from Stephen Waydo to Richa Gujarati, Jan. 22, 2021 <b>[SEALED]</b>	Appx60432-Appx60434
--	---------------------

CX-1806 - U.S. Patent Pub. No. 2017/0325744	Appx60435-Appx60461
---	---------------------

## COMPLAINANTS' PHYSICAL AND DEMONSTRATIVE EXHIBITS

CPX-0019aC - Photograph of Masimo Watch Article [SEALED]	Appx65014- Appx65015
CPX-0020aC - Photograph of Masimo Watch Article [SEALED]	Appx65016- Appx65017
CPX-0021aC - Photograph of Masimo Watch Article [SEALED]	Appx65018- Appx65019
CPX-0029aC - Photograph of Masimo Watch Article [SEALED]	Appx65022- Appx65023
CPX-0052aC - Photograph of Masimo Watch Article [SEALED]	Appx65024- Appx65025
CPX-0056aC - Photograph of Masimo Watch Article [SEALED]	Appx65028- Appx65029
CPX-0058aC - Photograph of Masimo Watch Article [SEALED]	Appx65030- Appx65031
CPX-0065aC - Photograph of Masimo Watch Article [SEALED]	Appx65032- Appx65033
CPX-0139aC - Photograph of 2016 Cercacor prototype [SEALED]	Appx65034- Appx65035
CPX-0140aC - Photograph of 2017 Cercacor prototype [SEALED]	Appx65036- Appx65037
CPX-0146aC - Photograph of Masimo Watch (W1) [SEALED]	Appx65040- Appx65042
CDX-0001C - Joe Kiani Demonstratives [SEALED]	Appx65064- Appx65065
CDX-0005C - Stephen Scruggs Demonstratives [SEALED]	Appx65066- Appx65074
CDX-0006C - Micah Young Demonstratives [SEALED]	Appx65075- Appx65114

CDX-0012C - Vijay Madiseti Rebuttal Demonstratives  
**[SEALED]** Appx65224-  
Appx65314

CDX-0015C - Daniel McGavock Demonstratives **[SEALED]** Appx65315-  
Appx65333

**RESPONDENT'S ADMITTED TRIAL EXHIBITS**

RX-0023 - Apple Watch In-Store Preview & Online Pre-Order  
Begin Friday Appx70001-  
Appx70004

RX-0035 - Webster, Design of Pulse Oximeters Appx70005-  
Appx70266

RX-0307C - Apple Engineering Requirements Specification, Apr.  
28, 2021 **[SEALED]** Appx70322-  
Appx70355

RX-0333 - Apple Watch Series 6 Delivers Breakthrough  
Wellness and Fitness Capabilities, Sept. 15, 2020 Appx70356-  
Appx70369

RX-0411 - U.S. Patent No. 7,620,212 Appx70389-  
Appx70423

RX-0504 - Optimization of Reflectance-Mode Pulse Oximeter  
Sensors, Wareing ("Kansas State 2") Appx70424

RX-0508 - Simulating Student Learning with a Novel "In-House"  
Pulse Oximeter Design, Yao and Warren ("Kansas State 1") Appx70425-  
Appx70438

RX-0670 – U.S. Patent No. 4,224,948 Appx70462-  
Appx70471

RX-1183C - Masimo's Sixth Supplemental Objections and  
Responses to Apple's Seventh Set of Interrogatories (Nos. 82-92),  
Apr. 3, 2022 and Appendix 82A.2 **[SEALED]** Appx70475-  
Appx70560

RX-1204C - Deposition of Joe Kiani **[SEALED]** Appx70592-  
Appx70609

RX-1206 - Deposition of Bilan Mushin, Feb. 22, 2022  
**[SEALED]** Appx70610-  
Appx70612

RX-1209C - Deposition of Steven Scruggs, Jan. 6, 2022  
**[SEALED]** Appx70613-  
Appx70628

RX-1467 - Masimo, Medical Monitoring Pioneer Announces the  
Limited Market Release of the Masimo W1 Watch for Appx70757-  
Consumers, May 2, 2022 Appx70762

### **RESPONDENT'S DEMONSTRATIVE EXHIBITS**

RDX-1 - Opening Demonstratives **[SEALED]** Appx70774-  
Appx70840

RDX-8 - Direct Demonstratives of Steven Warren **[SEALED]** Appx70841-  
Appx70954

RDX-11 - Stephen Scruggs Demonstratives Appx70955-  
Appx70956

### **ADDITIONAL DOCUMENTS**

USPTO Order Denying *Ex Parte* Reexamination for U.S. Patent  
10,912,502, May 30, 2024 Appx70957-  
Appx71010

USPTO Order Denying *Ex Parte* Reexamination for U.S. Patent  
10,945,648, May 30, 2024 Appx71011-  
Appx71035

Respondent Apple Inc.'s Emergency Motion to Suspend Any  
Remedy or Extend the Target Date and Stay Proceedings Pending  
Resolution of Any appeal of the Patent Office's Decision that  
United States Patent Nos. 10,638,941, 10, 595,731 and 9,572,499  
Are Unpatentable (ITC Inv. No. 337-TA-1266) Appx71036-  
Appx71222

CX-0635C-MASITC 01076914 - Appendix B - Masimo Watch  
R&D Expenditures, LTD Labor **[SEALED]** Appx71223-  
Appx71227

CX-0635C-MASITC-01076914 - Appendix B - Masimo Watch  
R&D Expenditures, R&D Summary **[SEALED]** Appx71228-  
Appx71231

CX-0624C-MASITC-01076803 – Appendix C - Watch Corporate  
Expenditures, v1, v2, v3 **[SEALED]** Appx71232-  
Appx71233

CX-0632C-MASITC-01076911 - Appendix F - Watch Sourcing  
IT and Recruiting Expenditures, Summary **[SEALED]** Appx71234-  
Appx71235

CX-0450C-MASITC-01076919 - Appendix M - Masimo Wrist  
Worn R&D Expenditures, Summary **[SEALED]** Appx71236-  
Appx71240

CX-0648C-MASITC-01076927 - Appendix S - Watch  
Headcount, v1 **[SEALED]** Appx71241-  
Appx71244

Mickle, Tripp, *Apple Keeps Losing Patent Cases. Its Solution:  
Rewrite the Rules*, N.Y. Times (Mar. 19, 2024) Appx71245-  
Appx71250

CERTIFICATE OF SERVICE

**CONFIDENTIAL MATERIAL OMITTED**

The material omitted from Appx9; Appx36; Appx41-44; Appx46-48; Appx108; Appx119; Appx121-122; Appx150-151; Appx153-154; Appx156-158; Appx187-190; Appx192-194; Appx196; Appx198; Appx218; Appx220-222; Appx265-276; Appx373; Appx13067-13069; Appx21846; Appx22790; Appx22954; Appx22956-22958; Appx22985; Appx22990; Appx23139; Appx23166; Appx23171-23174; Appx23238; Appx23249; Appx23251-23252; Appx23280-23281; Appx23283-23284; Appx23286-23288; Appx23317-23320; Appx23322-Appx23323; Appx23326; Appx23328; Appx23348; Appx23350-23352; Appx23395-23406; Appx23656; Appx23658; Appx23681-23682; 23688; Appx23791; Appx24147-24148; Appx40795-40798; Appx40996-40999; Appx41019-41026; Appx41029-41030; Appx41058-41062; Appx41077-41080; Appx41094-41097; Appx41108-41110; Appx51900-51924; Appx52602-52606; Appx52609; Appx52642-52645; Appx52791-52795; Appx52822-52824; Appx52911-52912; Appx52939-52941; Appx52980-52982; Appx53016-53019; Appx60425-60431; Appx60432-60434; Appx70322-70355; Appx70774; Appx70781-70783; and Appx70841-70876 contains Apple's confidential competitively sensitive product information subject to the Administrative Protective Order; the material omitted from Appx4579 and Appx53459-53461 contains competitively sensitive information regarding confidential agreements; the material omitted from Appx23439; Appx23441-23446; Appx23448; Appx23450-23453; Appx23455-23458; Appx23462; Appx23617; Appx23621; Appx23659-23665; Appx25251; Appx40483; Appx40582-40584; Appx40600-40601; Appx40605; Appx40652-40655; Appx40658-40662; Appx53491; Appx53492; Appx53497; Appx53499; Appx53503; Appx53506; Appx65064-65075; Appx65075; Appx65104-65105; Appx65315; Appx65321-65232; and Appx71223-71244 contains Masimo's confidential competitively sensitive financial information subject to the Administrative Protective Order; the material omitted from Appx311-316; Appx23667-23674; Appx40579-40581; Appx40585-40599; Appx40602-40604; Appx40610-40614; and Appx40631-40633 contains Masimo's confidential competitively sensitive financial and manufacturing information subject to the Administrative Protective Order; the material omitted from Appx473-474; Appx62; and Appx23176-23178 contains Masimo's confidential competitively sensitive manufacturing information subject to the Administrative Protective Order; the material omitted from Appx13047; Appx14129-14140; Appx205-206; Appx211; Appx21848; Appx22282-22286; Appx23197; Appx23204; Appx23335-23336; Appx23341; Appx23408-23416; Appx23434-23436; Appx23454; Appx23642; Appx23644-23645; Appx23647-23649; Appx23685-23687; Appx23693-23697; Appx23704; Appx25253-25260; Appx278-286; Appx2809-

2852; Appx2923-2937; Appx304-306; Appx309; Appx3708; Appx3710-3711; Appx3718; Appx3722; Appx3725; Appx3727; Appx3732; Appx3733; Appx3735; Appx40229-40232; Appx40346-40371; Appx40407-40422; Appx40431-40434; Appx40438-40442; Appx40486-40494; Appx40495-40506; Appx40512-40521; Appx40525-40528; Appx40547-40555; Appx40560-40574; Appx40803-40822; Appx41217-41221; Appx41350-41356; Appx53070-53095; Appx53107-53151; Appx53222-53234; Appx53236-53252; Appx53256-53361; Appx53362-53365; Appx53813-53838; Appx53927-53941; Appx54064-54226; Appx54227-54266; Appx55229-55354; Appx55359-55376; Appx55386-55399; Appx57317-57324; Appx57394--57409; Appx57410-57412; Appx57615-57618; Appx60136-60153; Appx60184-60212; Appx65014-65019; Appx65022-65025; Appx65028-65037; Appx65040-65074; Appx65207; Appx65224; Appx65267-65268; Appx67; Appx6701-6703; Appx6705; Appx6732-6736; Appx6852-6854; Appx6937-6950; Appx70475; Appx70484-70491; Appx70504-70513; Appx70518-70559; Appx70610-70613; Appx70615-70617; Appx70619-70628; Appx70833-70835; Appx70948-70950; Appx70955-70956; and Appx74 contains Masimo's confidential competitively sensitive product information subject to the Administrative Protective Order; the material omitted from Appx23707-23709; Appx318; Appx320-328; Appx40634; and Appx70592-70594 contains Masimo's confidential competitively sensitive product and financial information subject to the Administrative Protective Order; the material omitted from Appx176; Appx179; Appx22788-22789; and Appx22791 contains Masimo's confidential information detailing non-public patent prosecution subject to the Administrative Protective Order; the material omitted from Appx404-405; Appx457; Appx460-461; Appx464; Appx24103-24104; Appx25387; and Appx25389 contains Apple's confidential competitively sensitive financial and sales information subject to the Administrative Protective Order; the material omitted from Appx52602-52608 contains confidential competitively sensitive product of a third party.

**WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING AUTHORITY**

International application No.  
PCT/US2009/052756

---

**Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

---

**1. Statement**

Novelty (N)	Yes: Claims	<u>8-17, 19-24, 28-30</u>
	No: Claims	<u>1-7, 18, 25-27, 31-36</u>
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-36</u>
Industrial applicability (IA)	Yes: Claims	<u>1-36</u>
	No: Claims	

**2. Citations and explanations**

**see separate sheet**



**WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING  
AUTHORITY (SEPARATE SHEET)**

International application No.

PCT/US2009/052756

**Re Item V.**

**1 Reference is made to the following documents:**

- D1 : WO 00/25112 A (ROLFE PETER [GB]) 4 May 2000 (2000-05-04)
- D2 : US 6816241 B2 (GRUBISIC DRAGAN [US] GRUBISIC DRAGAN [US] ET AL) 09 November 2004 (2004-11-09)
- D3 : US 2006/211924 A1 (DALKE DAVID [US] ET AL) 21 September 2006 (2006-09-21) cited in the application
- D4 : US 6 172 743 B1 (KLEY VIC [US] ET AL) 9 January 2001 (2001-01-09)
- D5 : US 5 676 143 A (SIMONSEN JAN HENNING [DK] ET AL) 14 October 1997 (1997-10-14)
- D6 : US 2004/049237 A1 (LARSON DENNIS E [US] ET AL) 11 March 2004 (2004-03-11)

US 4 258 719 A (LEWYN LANNY L) 31 March 1981 (1981-03-31)

**2 INDEPENDENT CLAIM 1**

- 2.1** The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT. Document D1 discloses (the references in parentheses applying to this document):

A method of measuring an analyte (cf. abstract) based on multiple streams of optical radiation measured from a measurement site (cf. figure 2), said method comprising:  
emitting a sequence of optical radiation pulses to the measurement site (cf. abstract, page 7, lines 16-23) ;  
detecting at a first location (12a) a first stream of optical radiation from the measurement site;  
detecting at least at one additional location (12b) different from the first location an additional stream of optical radiation from the measurement site; and  
determining an output measurement value indicative of the analyte based on the

**WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING  
AUTHORITY (SEPARATE SHEET)**

International application No.

PCT/US2009/052756

detected streams of optical radiation (cf. abstract, page 8, lines 4-6) figure 2).

Hence, the subject-matter of claim 1 is disclosed in document D1.

- 2.2 Bearing in mind that an array of detectors allows detecting at a plurality of locations streams of optical radiation (cf. D1, page 8, lines 14-17), the subject-matter of claim 1 is disclosed also in documents D2-D5 (cf. the corresponding passages cited in the search report).

**3 INDEPENDENT CLAIM 7**

- 3.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 7 is not new in the sense of Article 33(2) PCT. Document D3 discloses (the references in parentheses applying to this document):

A front-end interface (4030) for a noninvasive, physiological sensor, said front-end interface comprising:

a set of inputs configured to receive signals (2500, cf. figures 7 and 40) from a plurality of detectors (cf. figures 2400, cf. paragraph 58, figures 25,26,40) in the sensor;

a set of transimpedance amplifiers (implicit: cf. paragraphs 72, 107) configured to convert the signals from the plurality of detectors into an output signal having a stream for each of the plurality of detectors; and

an output configured to provide the output signal (cf. figure 40).

**4 INDEPENDENT CLAIM 15**

- 4.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject matter of claim 15 does not involve an inventive step in the sense of Article 33(3)PCT.

**WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING  
AUTHORITY (SEPARATE SHEET)**

International application No.

PCT/US2009/052756

- 4.1.1 Document D2, discloses (cf. passages cited in the search report) a device from which the subject-matter of independent claim 15 differs in that:

the digital conversion is carried out by switched-capacitor circuits.

- 4.1.3 In document D2 no details are given about the circuits for A/D conversion. The problem to be solved by the present invention may therefore be regarded as to provide a specific embodiment of such circuits.

- 4.1.4 D6 discloses (cf. paragraph 42) switched-capacitor circuits for A/D conversion. The skilled person would therefore regard it as a normal option to include this feature in the device described in document D2, in order to solve the problem posed. The subject-matter of claim 15 thus cannot be considered inventive (Article 33(3) PCT).

**5 INDEPENDENT CLAIM 18**

- 5.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 18 is not new in the sense of Article 33(2) PCT. The subject-matter of claim 18 is just directed to the essential features of a processor unit having inputs signals from a detector array, said signals being converted in digital form and then processed by a signal processor. These essential features are disclosed in all documents D2-D4 (cf. the corresponding passages cited in the search report).

**6 INDEPENDENT CLAIM 25**

- 6.1 The same reasoning applies, mutatis mutandis, to the subject-matter of independent claim 25, which is just directed to the essential features of a multi-stream emitter and which is disclosed in all documents D2-D4 (cf. the corresponding passages cited in the search report), which therefore is therefore also considered not new (Articles 33(1) and 33(2) PCT).

**7 DEPENDENT CLAIMS 2-6, 8-14, 16, 17, 19-24, 26-36**

**WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING  
AUTHORITY (SEPARATE SHEET)**

International application No.

PCT/US2009/052756

- 7.1 The additional features of dependent claims 2-6, 26, 27, and 31-36 are disclosed in at least one of the documents D1-D5 (cf. the corresponding passages cited in the search report) and therefore the subject-matter of these claims is not new.
- 7.2 The additional features of dependent claims 8-14, 16, 17, 19-24, and 28-30 are just some of several straightforward possibilities from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill.

CX-1622

Electronic Acknowledgement Receipt	
<b>EFS ID:</b>	11264414
<b>Application Number:</b>	12829352
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	8366
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	20995
<b>Filer:</b>	Jarom D. Kesler/Sabrina Jacob
<b>Filer Authorized By:</b>	Jarom D. Kesler
<b>Attorney Docket Number:</b>	MLHUM.002C1
<b>Receipt Date:</b>	25-OCT-2011
<b>Filing Date:</b>	01-JUL-2010
<b>Time Stamp:</b>	19:16:22
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	no
------------------------	----

**File Listing:**

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_MLHUM_002C1.PDF	72865 c4263e8c9da431137fa5607bc485ed12959 c98b6	yes	2

CX-1622

Multipart Description/PDF files in .zip description					
Document Description			Start	End	
Transmittal Letter			1	1	
Information Disclosure Statement (IDS) Form (SB08)			2	2	
<b>Warnings:</b>					
<b>Information:</b>					
2	Foreign Reference	WO_00_025112.PDF	959184	no	25
			6d973a89434b07869f6334035cd433d850762b07		
<b>Warnings:</b>					
<b>Information:</b>					
3	Non Patent Literature	ISR_MLHUM002VPC.PDF	579672	no	14
			684258e0a9496d37cf9fee71dac0d0839784bbed		
<b>Warnings:</b>					
<b>Information:</b>					
4	Non Patent Literature	IPRP_MLHUM002VPC.PDF	276902	no	8
			369c7cf09966b90f36bba9faa006c7b8453775dc		
<b>Warnings:</b>					
<b>Information:</b>					
<b>Total Files Size (in bytes):</b>			1888623		
<p>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>  If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>  If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>  If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p>					

Docket No.: MLHUM.002C1

Customer No. 20995

**INFORMATION DISCLOSURE STATEMENT**

Applicants : Poeze, et al.  
App. No : 12/829,352  
Filed : July 1, 2010  
For : MULTI-STREAM DATA  
COLLECTION SYSTEM FOR  
NONINVASIVE MEASUREMENT OF  
BLOOD CONSTITUENTS  
Examiner : Chen, Tse W.  
Art Unit : 2877  
Conf No. : 8366

**CERTIFICATE OF EFS WEB  
TRANSMISSION**

I hereby certify that this correspondence, and any other attachment noted on the automated Acknowledgement Receipt, is being transmitted from within the Pacific Time zone to the Commissioner for Patents via the EFS Web server on:

October 25, 2011

(Date)

/Jarom Kesler/

Jarom D. Kesler, Reg. No. 57,046

Mail Stop Amendment  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

Enclosed for filing in the above-identified application is a PTO/SB/08 Equivalent listing 9 references, of which 3 are enclosed/submitted.

This Information Disclosure Statement is being filed before the receipt of a first Office Action on the merits, and presumably no fee is required. If a first Office Action on the merits was mailed before the mailing date of this Statement, the Commissioner is authorized to charge the fee set forth in 37 C.F.R. § 1.17(p) to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON &amp; BEAR, LLP

Dated: October 25, 2011

By: /Jarom Kesler/  
Jarom D. Kesler  
Registration No. 57,046  
Attorney of Record  
Customer No. 20995  
(949) 760-0404

12089095



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/829,352	07/01/2010	Jeroen Poeze	MLHUM.002C1

CONFIRMATION NO. 8366

## PUBLICATION NOTICE

20995

KNOBBE MARTENS OLSON & BEAR LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614



\*OC000000045314757\*

**Title:**MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

**Publication No.**US-2011-0004082-A1

**Publication Date:**01/06/2011

## NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publicly available Searchable Databases via the Internet at [www.uspto.gov](http://www.uspto.gov). The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at [www.uspto.gov](http://www.uspto.gov) using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <http://pair.uspto.gov/>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



Docket No.: MLHUM.002C1

October 12, 2010

App. No.: 12/829,352

Page 1 of 1

Please Direct All Correspondence to Customer Number 20995

**RESCISSION OF ANY PRIOR DISCLAIMERS AND REQUEST TO REVISIT ART**

Applicant : Jeroen Poeze, et al.  
 App. No : 12/829,352  
 Filed : July 1, 2010  
 For : MULTI-STREAM DATA COLLECTION  
 SYSTEM FOR NONINVASIVE  
 MEASUREMENT OF BLOOD  
 CONSTITUENTS  
 Examiner : Unknown  
 Art Unit : 2877  
 Conf # : 8366

**CERTIFICATE OF EFS WEB  
TRANSMISSION**

I hereby certify that this correspondence, and any other attachment noted on the automated Acknowledgement Receipt, is being transmitted from within the Pacific Time zone to the Commissioner for Patents via the EFS Web server on:

October 12, 2010

(Date)

/Jarom Kesler/

Jarom D. Kesler, Reg. No. 57,046

Commissioner for Patents  
 P.O. Box 1450  
 Alexandria, VA 22313-1450

Dear Sir:

The claims of the present application are different and possibly broader in scope than the claims pursued in the parent application(s). To the extent any prior amendments or characterizations of the scope of any claim or referenced art could be construed as a disclaimer of any subject matter supported by the present disclosure, Applicant hereby rescinds and retracts such disclaimer. Accordingly, the references previously considered in the parent application(s) may need to be revisited.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

Dated: October 12, 2010

/Jarom Kesler/

Jarom D. Kesler  
 Registration No. 57,046  
 Attorney of Record  
 Customer No. 20995  
 (949) 760-0404

9814348

CX-1622

Electronic Acknowledgement Receipt	
EFS ID:	8605191
Application Number:	12829352
International Application Number:	
Confirmation Number:	8366
Title of Invention:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
First Named Inventor/Applicant Name:	Jeroen Poeze
Customer Number:	20995
Filer:	Jarom D. Kesler/Valerie Jones
Filer Authorized By:	Jarom D. Kesler
Attorney Docket Number:	MLHUM.002C1
Receipt Date:	12-OCT-2010
Filing Date:	01-JUL-2010
Time Stamp:	14:23:20
Application Type:	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	no
------------------------	----

**File Listing:**

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	mlhum.pdf	39100 2710dac225e304a4797f55a02e9a2510e313e334	no	1

**Warnings:****Information:**

Total Files Size (in bytes):

39100

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
12/829,352	07/01/2010	2877	1594	MLHUM.002C1	22	3

CONFIRMATION NO. 8366

## UPDATED FILING RECEIPT



\*OC000000043765830\*

20995  
 KNOBBE MARTENS OLSON & BEAR LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

Date Mailed: 10/01/2010

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

## Applicant(s)

Jeroen Poeze, Mission Viejo, CA;  
 Marcelo Lamego, Coto De Caza, CA;  
 Sean Merritt, Lake Forest, CA;  
 Cristiano Dalvi, Mission Viejo, CA;  
 Hung Vo, Garden Grove, CA;  
 Johannes Bruinsma, Mission Viejo, CA;  
 Ferdyan Lesmana, Irvine, CA;  
 Massi Joe E. Kiani, Laguna Niguel, CA;

**Power of Attorney:** The patent practitioners associated with Customer Number 20995

## Domestic Priority data as claimed by applicant

This application is a CON of 12/534,827 08/03/2009  
 which claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/091,732 08/25/2008  
 This application 12/829,352  
 is a CON of 12/497,528 07/02/2009  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008

and is a CIP of 29/323,409 08/25/2008 PAT D,621,516  
 and is a CIP of 29/323,408 08/25/2008 PAT D,606,659  
 This application 12/829,352  
 is a CON of 12/497,523 07/02/2009  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008 PAT D,621,516  
 and is a CIP of 29/323,408 08/25/2008 PAT D,606,659

### Foreign Applications

**If Required, Foreign Filing License Granted:** 07/16/2010

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/829,352**

**Projected Publication Date:** 01/06/2011

**Non-Publication Request:** No

**Early Publication Request:** No  
**Title**

MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

### Preliminary Class

356

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application

page 2 of 3

serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

### **LICENSE FOR FOREIGN FILING UNDER**

#### **Title 35, United States Code, Section 184**

#### **Title 37, Code of Federal Regulations, 5.11 & 5.15**

#### **GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

#### **NOT GRANTED**

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
**United States Patent and Trademark Office**  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/829,352	07/01/2010	Jeroen Poeze	MLHUM.002C1

**CONFIRMATION NO. 8366****POA ACCEPTANCE LETTER**

20995

KNOBBE MARTENS OLSON & BEAR LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614



\*OC000000043765776\*

Date Mailed: 10/01/2010

**NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY**

This is in response to the Power of Attorney filed 09/22/2010.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/rdpaz/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

Docket No.: MLHUM.002C1

September 22, 2010

Page 1 of 1

Please Direct All Correspondence to Customer Number 20995

---

**RESPONSE TO FORMALITIES NOTICE**

Applicant : Poeze, et al.

App. No : 12/829,352

Filed : July 1, 2010

For : MULTI-STREAM DATA  
COLLECTION SYSTEM FOR  
NONINVASIVE MEASUREMENT OF  
BLOOD CONSTITUENTS

Art Unit : 2877

Conf No. : 8366

**CERTIFICATE OF EFS WEB  
TRANSMISSION**

I hereby certify that this correspondence, and any other attachment noted on the automated Acknowledgement Receipt, is being transmitted from within the Pacific Time zone to the Commissioner for Patents via the EFS Web server on:

September 22, 2010

(Date)

/Jarom Kesler/

Jarom D. Kesler, Reg. No. 57,046

**Mail Stop Missing Parts  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450**

Dear Sir:

The above-captioned application was filed without a Declaration and/or filing fees. Enclosed in compliance with 37 CFR 1.53(f) are the following.

- (X) A Declaration in 3 pages.
- (X) General Power of Attorney and Statement Under 37 CFR 3.73(b) in 2 pages.
- (X) Fees will be paid via EFS Web. Extension of time is requested by payment of any extension fee.

The Commissioner is hereby authorized to charge any additional fees which may be required, now or in the future, or credit any overpayment, to Account No. 11-1410.

/Jarom Kesler/

Jarom D. Kesler  
Registration No. 57,046  
Attorney of Record  
Customer No. 20,995  
(949) 760-0404

9716400



Docket No.: MLHUM.002C1

Customer No. 20995

**STATEMENT UNDER 37 CFR § 3.73(b)  
ESTABLISHMENT OF ASSIGNEE**

Applicants	:	Poeze, et al.
App. No.	:	12/829352
Filed	:	July 1, 2010
For	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner	:	Unknown
Group Art Unit	:	2877

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

This document is being filed with a copy of a Power of Attorney signed by the Assignee. This Statement sets forth the chain of title of the above-identified application.

Masimo Laboratories, Inc., a corporation, is the Assignee of the entire right, title, and interest of the above-referenced application by virtue of:

The Assignment from the inventors to the Assignee recorded in the United States  
Patent and Trademark Office on January 8, 2010, at Reel 023757, and Frame 0332.

The undersigned is an agent of Customer Number 20995 and is authorized to act on behalf of the Assignee. Please recognize or change the correspondence address for the above-identified application to  
**Customer No. 20995.**

Respectfully submitted,  
KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: September 22, 2010

By: /Jarom Kesler  
Jarom D. Kesler  
Registration No. 57,046  
Attorney of Record  
Customer No. 20995  
(949) 760-0404

9288173

Docket No.: MLABS..000GEN

Customer No. 20,995

**REVOCATION  
AND  
GENERAL POWER OF ATTORNEY**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

The undersigned is an empowered representative of the Assignee and hereby appoints the registrants of Knobbe, Martens, Olson & Bear, LLP, **Customer No. 20,995**, as attorneys and agents to represent the Assignee before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned to the Assignee according to the USPTO assignment records or assignment documents supplied with an accompanying Statement Under 37 CFR § 3.73(b). This appointment is to be to the exclusion of the inventor(s) and his attorney(s) in accordance with the provisions of 37 CFR § 3.71.

All previous powers of attorney for the below named Assignee are hereby revoked.

A Statement Under 37 CFR § 3.73(b), signed by a registrant of Knobbe, Martens, Olson & Bear, LLP, is attached setting forth a full chain of title for the subject application owned by the Assignee named below.

Please recognize or change the correspondence address for the above-identified application to **Customer No. 20,995**.

By:



Date: 9-8-04

Name: Joe E. Kiani

Title: President and CEO

Assignee: MASIMO LABORATORIES, INC.

Address: 40 Parker, Irvine, CA 92618

H:\DOCS\JMG\JMG-6382.DOC  
072804

**DECLARATION FOR UTILITY OR DESIGN APPLICATION  
UNDER 37 CFR 1.63**

Docket No.: MLHUM.002A

Page 1 of 3

Title: MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE  
MEASUREMENT OF BLOOD CONSTITUENTS

Inventors: Poeze, Jeroen; Lamego, Marcelo; Merritt, Sean; Dalvi, Cristiano; Vo, Hung;  
Bruinsma, Johannes; Lesmana, Ferydan; Kiani, Massi Joe E.

Please Direct All Correspondence to Customer Number 20995

This Declaration is directed to the invention that was filed as Application No. 12/534,827, on August 3, 2009

As a below named inventor:

I believe the inventors named below to be the original and first inventors of the subject matter which is described and claimed and for which a patent is sought;


I have reviewed and understand the contents of the above-identified application, including the claims, and any amendment filed herewith or identified above;

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56;

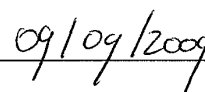
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful, false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of **first** inventor: Jeroen Poeze

Signature:



Date:



Citizenship:

NL

Mailing Address:

21622 Marguerite Parkway #342, Mission Viejo, CA 92692

**DECLARATION FOR UTILITY OR DESIGN APPLICATION  
UNDER 37 CFR 1.63**

Docket No.: MLHUM.002A

Page 2 of 3

Title: MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE  
MEASUREMENT OF BLOOD CONSTITUENTS

Inventors: Poeze, Jeroen; Lamego, Marcelo; Merritt, Sean; Dalvi, Cristiano; Vo, Hung;  
Bruinsma, Johannes; Lesmana, Ferydan; Kiani, Massi Joe E.

Please Direct All Correspondence to Customer Number 20995

Full name of **second** inventor: Marcelo Lamego

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Citizenship: \_\_\_\_\_

BR

Mailing Address: \_\_\_\_\_

18 Lyra Way, Coto De Caza, CA 92679

Full name of **third** inventor: Sean Merritt

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Citizenship: \_\_\_\_\_

US

Mailing Address: \_\_\_\_\_

22273 Vista Verde Drive, Lake Forest, CA 92630

Full name of **fourth** inventor: Cristiano Dalvi

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Citizenship: \_\_\_\_\_

BR

Mailing Address: \_\_\_\_\_

21622 Marguerite Pkwy #6, Mission Viejo, CA 92692

Full name of **fifth** inventor: Hung Vo

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Citizenship: \_\_\_\_\_

US

Mailing Address: \_\_\_\_\_

8801 Mays Ave, Garden Grove, CA 92844

**DECLARATION FOR UTILITY OR DESIGN APPLICATION  
UNDER 37 CFR 1.63**

Docket No.: MLHUM.002A

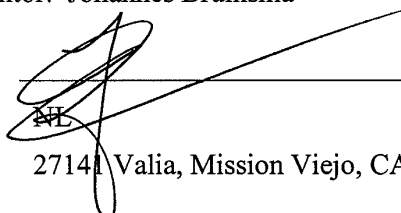
Page 3 of 3

Title: MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE  
MEASUREMENT OF BLOOD CONSTITUENTS

Inventors: Poeze, Jeroen; Lamego, Marcelo; Merritt, Sean; Dalvi, Cristiano; Vo, Hung;  
Bruinsma, Johannes; Lesmana, Ferydan; Kiani, Massi Joe E.

Please Direct All Correspondence to Customer Number 20995

Full name of **sixth** inventor: Johannes Bruinsma

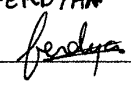
Signature: 

Date: 09/09/09

Citizenship: NL

Mailing Address: 27141 Valia, Mission Viejo, CA 92691

Full name of **seventh** inventor: <sup>F.L.</sup> ~~Ferydan~~ Lesmana  
**FERDYAN**

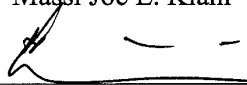
Signature: 

Date: 09/09/2009

Citizenship: ID

Mailing Address: 42 New Season, Irvine, CA 92602

Full name of **eighth** inventor: Massi Joe E. Kiani

Signature: 

Date: 09.09/2009

Citizenship: US

Mailing Address: 35 Brindisi, Laguna Niguel, CA 92677

Send Correspondence To:  
KNOBBE, MARTENS, OLSON & BEAR, LLP  
Customer No. 20995  
7568455

Electronic Patent Application Fee Transmittal				
<b>Application Number:</b>	12829352			
<b>Filing Date:</b>	01-Jul-2010			
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS			
<b>First Named Inventor/Applicant Name:</b>	Massi Joe E. Kiani			
<b>Filer:</b>	Jarom D. Kesler/Nadin Hamoui			
<b>Attorney Docket Number:</b>	MLHUM.002C1			
Filed as Large Entity				
<b>Utility under 35 USC 111(a) Filing Fees</b>				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
<b>Basic Filing:</b>				
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
Late filing fee for oath or declaration	1051	1	130	130
<b>Petition:</b>				
<b>Patent-Appeals-and-Interference:</b>				
<b>Post-Allowance-and-Post-Issuance:</b>				
<b>Extension-of-Time:</b>				

CX-1622

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Miscellaneous:				
Total in USD (\$)				130

CX-1622

<b>Electronic Acknowledgement Receipt</b>	
<b>EFS ID:</b>	8477369
<b>Application Number:</b>	12829352
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	8366
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Massi Joe E. Kiani
<b>Customer Number:</b>	20995
<b>Filer:</b>	Jarom D. Kesler/ThuyQuyen Nguyen
<b>Filer Authorized By:</b>	Jarom D. Kesler
<b>Attorney Docket Number:</b>	MLHUM.002C1
<b>Receipt Date:</b>	22-SEP-2010
<b>Filing Date:</b>	01-JUL-2010
<b>Time Stamp:</b>	19:25:57
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	\$130
RAM confirmation Number	7101
Deposit Account	111410
Authorized User	KNOBBE MARTENS OLSON AND BEAR
<p>The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:</p> <p>Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)</p> <p>Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)</p>	

Page 857 of 1082



CX-1622

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	Response.pdf	35182	no	1
			fc74b007988d8d2cf79e12430ec70c3a513ea522		
Warnings:					
Information:					
2		statement.pdf	67279	yes	2
			a79b6b0db62d4a97b8434ae3816e03a42586cf6b		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Assignee showing of ownership per 37 CFR 3.73(b).		1	1	
	Power of Attorney		2	2	
Warnings:					
Information:					
3	Oath or Declaration filed	Declaration.pdf	134267	no	3
			871448d1c1a951d241613aa5d7559497cfd62b36		
Warnings:					
Information:					
4	Fee Worksheet (PTO-875)	fee-info.pdf	30008	no	2
			9fdd3d7d700e07b1928201ec67b9fec1615a71f1		
Warnings:					
Information:					
Total Files Size (in bytes):			266736		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

CX-1622

PTO/SB/08 Equivalent

# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Multiple sheets used when necessary)

SHEET 1 OF 1

Application No.	12/829,352
Filing Date	July 1, 2010
First Named Inventor	Kiani, et al.
Art Unit	2877
Examiner	Unknown
Attorney Docket No.	MLHUM.002C1

## U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	4,267,844	05/19/1981	Yamanishi	
	2	4,655,225	04/07/1987	Dähne, et al.	
	3	4,781,195	11/01/1988	Martin	
	4	4,805,623	02/21/2989	Jöbsis	
	5	5,028,787	07/02/1991	Rosenthal, et al.	
	6	5,077,476	12/31/1991	Rosenthal	
	7	5,137,023	08/11/1992	Mendelson, et al.	
	8	5,337,745	08/16/1994	Benaron	

## FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document Country Code-Number-Kind Code Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T <sup>1</sup>
	9	EP419223	03/27/1991	Minnesota Mining and Manufacturing Company		

## NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	10	Burritt, Mary F.; Current Analytical Approaches to Measuring Blood Analytes; Vol. 36; No. 8(B); 1990	
	11	Hall, et al., Jeffrey W.; Near-Infrared Spectrophotometry: A New Dimension in Clinical Chemistry; Vol. 38; No. 9; 1992	
	12	Kuenstner, et al., J. Todd; Measurement of Hemoglobin in Unlysed Blood by Near-Infrared Spectroscopy; Vol. 48; Number 4, 1994	
	13	Manzke, et al., B., Multi Wavelength Pulse Oximetry in the Measurement of Hemoglobin Fractions; Vol. 2676	
	14	Naumenko, E. K.; Choice of Wavelengths for Stable Determination of Concentrations of Hemoglobin Derivatives from Absorption Spectra of Erythrocytes; Vol. 63; No. 1; pp. 60-66 January – February 1996; Original article submitted November 3, 1994	
	15	Schmitt, Joseph M.; Simple Photon Diffusion Anaylsis of the Effects of Multiple Scattering on Pulse Oximetry; March 14, 1991; revised August 30, 1991	
	16	Schmitt, et al., Joseph M.; Measurement of Blood Hematocrit by Dual-Wavelength near-IR Photoplethysmography; Vol. 1641; 1992	
	17	Schnapp, et al., L.M.; Pulse Oximetry. Uses and Abuses.; Chest 1990; 98; 1244-1250 DOI 10.1378/Chest.98.5.1244	

1309968

Examiner Signature	Date Considered
--------------------	-----------------

\***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

CX-1622

Electronic Acknowledgement Receipt	
EFS ID:	8194921
Application Number:	12829352
International Application Number:	
Confirmation Number:	8366
Title of Invention:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
First Named Inventor/Applicant Name:	Massi Joe E. Kiani
Customer Number:	20995
Filer:	Jarom D. Kesler/Shirley Martinez
Filer Authorized By:	Jarom D. Kesler
Attorney Docket Number:	MLHUM.002C1
Receipt Date:	11-AUG-2010
Filing Date:	01-JUL-2010
Time Stamp:	14:39:36
Application Type:	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	no
------------------------	----

**File Listing:**

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	EP0419223A2.pdf	3002370 177d9288ef92992d659539a08cda01726aff14b	no	51

**Warnings:****Information:**

CX-1622

2	NPL Documents	npl10.pdf	569626	no	5
			475a7368b7fb45d3a43b0e2897c4ccb9f8e43575		
Warnings:					
Information:					
3	NPL Documents	npl11.pdf	823239	no	9
			ffc50816a81bcf3aa03248e0f7439509488543ce		
Warnings:					
Information:					
4	NPL Documents	npl12.pdf	519482	no	5
			33c3b926aa0d600cfabf5217b6a21f98711bb76e		
Warnings:					
Information:					
5	NPL Documents	npl13.pdf	589586	no	9
			83d32b1dd7364db8f909c4ca816ddcfbcde81781		
Warnings:					
Information:					
6	NPL Documents	npl14.pdf	432914	no	6
			15a3cf7a0a95a3f15f91715b6b88f5604c1d772e		
Warnings:					
Information:					
7	NPL Documents	npl15.pdf	1896836	no	10
			874668d639311da247832ad99f94deda01cd7a8		
Warnings:					
Information:					
8	NPL Documents	npl16.pdf	742243	no	12
			5e9be78a3d5337436ce10e23b7189e8e17255921		
Warnings:					
Information:					
9	NPL Documents	npl17.pdf	791352	no	9
			95de21607cc2ba1f9ebcc75b41db13ebb4a9ee21		
Warnings:					
Information:					
10		002C1.pdf	111950	yes	2
			e50f4150bb5e53981fae34a07bf4877c3c71c8a7		

CX-1622

Multipart Description/PDF files in .zip description			
Document Description	Start	End	
Transmittal Letter	1	1	
Information Disclosure Statement (IDS) Filed (SB/08)	2	2	

**Warnings:**

**Information:**

<b>Total Files Size (in bytes):</b>	9479598
-------------------------------------	---------

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**  
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**  
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**  
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



(11) Publication number: **0 419 223 A2**

(12)

## EUROPEAN PATENT APPLICATION

(21) Application number: **90310219.2**

(51) Int. Cl.<sup>5</sup>: **G01N 21/35, G01N 33/48,  
G06F 15/20, G06F 15/336**

(22) Date of filing: **18.09.90**

(30) Priority: **18.09.89 US 408890**

(43) Date of publication of application:  
**27.03.91 Bulletin 91/13**

(84) Designated Contracting States:  
**DE DK ES FR GB IT NL SE**

(71) Applicant: **MINNESOTA MINING AND  
MANUFACTURING COMPANY**  
3M Center, P.O. Box 33427  
St. Paul, Minnesota 55133-3427(US)

Applicant: **THE BOARD OF REGENTS OF THE  
UNIVERSITY OF WASHINGTON**  
201 Administration Building, The Graduate  
School AG-10  
Seattle, Washington 98195(US)

(72) Inventor: **Callis, James B., C/o Board of**

**Regents of the  
Univ. of Washington, 201 Administration  
Building  
The Grad. School AG-10 Seattle, WA  
98195(US)**

Inventor: **Osten, David W., C/o Minnesota  
Mining and  
Manufact. Comp., 2501 Hudson Road,  
P.O.Box 33427**

**St. Paul, Minnesota 55133-3427(US)**  
Inventor: **Carim, Hatim M., C/o Minnesota  
Mining and  
Manufact. Comp., 2501 Hudson Road,  
P.O.Box 33427**

**St. Paul, Minnesota 55133-3427(US)**

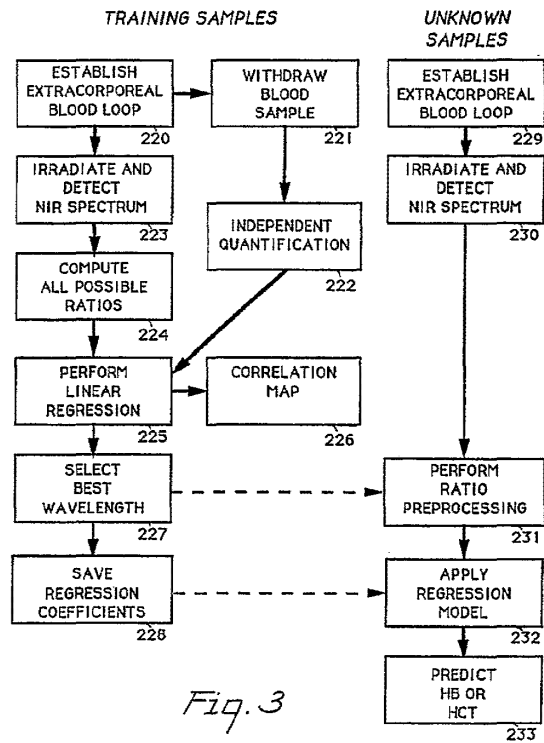
(74) Representative: **Baillie, Iain Cameron et al  
c/o Ladas & Parry Isartorplatz 5  
W-8000 München 2(DE)**

(54) **Characterizing biological matter in a dynamic condition using near infrared spectroscopy.**

(57) A method is provided for predicting a property of a matter of biological origin, such as biological fluid, containing water, in a dynamic condition where the biological fluid may be approximated to contain two compartments where one compartment has a proportionally larger or smaller amount of water than the other compartment having the property of interest. The method involves establishing a training set in the near-infrared (NIR) region with independent quantification of the property of the fluid using known techniques. The training set is mathematically analyzed according to a correlation developed by regression analysis after employment of a pre-processing technique such as a multiple derivative transformation of spectra or a ratioing of two wavelengths in the spectra. The result is a mathematical transformation equation which quantitatively relates spectral intensities at specific wavelengths to the property of interest. This transformation equation may be applied to unknown samples so as to predict their properties, thereby eliminating need for the reference method except for validation or recalibration. The method provides rapid and accurate prediction of the property of the unknown sample, which may be the property of hematocrit or hemoglobin concentration in whole animal blood. Other analyses of properties in the biological fluid such as oxygen saturation in hemoglobin in whole animal blood may be included in the mathematical analysis to further refine the prediction of the property of interest. Also, a loop from the patient is disclosed for the purpose of monitoring the property of interest nearly simultaneously with changes in that property of interest.

EP 0 419 223 A2

## EP 0 419 223 A2





EP 0 419 223 A2

**CHARACTERIZING BIOLOGICAL MATTER IN A DYNAMIC CONDITION USING NEAR INFRARED SPECTROSCOPY**Field of the Invention

The present invention relates to the analysis of a sample of matter of biological origin in a dynamic condition using the near infrared (NIR) spectrum of that biological matter having a water content. The method permits prediction of a property of interest because the biological matter may be approximated to contain two compartments where one compartment has a proportionally larger or smaller amount of water than the other compartment having the property of interest. Analysis of an unknown sample in a dynamic condition is achieved by use of mathematical techniques developed using a NIR spectral training set of known samples and independent quantification of the property of interest in the known samples in that training set.

Background of the Invention

15

Presence of water in an organism is the common denominator of life. The corpus of an organism is compartmentalized with each compartment capable of being distinguished by the amount of water it contains. The processes of osmosis and reverse osmosis in an organism act to stabilize this compartmentalization.

Determination of the volume fraction or percentage concentration of components other than water in the various compartments of biological matter, such as tissue or blood, is often critical to the determination of the well-being or homeostasis of the organism. Whether in the botanical, medical, zoological or veterinary arts, because the circulation of biological fluid or existence of certain biological tissue in an organism is necessary for life, the diagnosis of such biological matter provides an excellent medium to assess the homeostatic condition of the organism.

Blood of animals circulates essential nutrients of life. Erythrocytes, red blood cells, flowing in the blood plasma carry oxygen to all other cells of the organism. Hematocrit is the volume fraction of agglomerated erythrocytes in whole blood. Hemoglobin is the chemical molecule in the erythrocytes which transports oxygen to the cells. Hemoglobin may take several forms depending on the presence or absence of oxygen or other chemicals which may be bonded to active sites in the hemoglobin molecule. Hematocrit in whole blood has been found to have a suitable direct mathematical correlation to the concentration of hemoglobin, providing the blood has few or no lysed erythrocytes.

Water is omnipresent in whole blood. Hemoglobin is dissolved in the erythrocytes, while plasma is principally water. But the amount of water in which hemoglobin is dissolved, and hence in erythrocytes, is comparatively less than the amount of water in the plasma.

Clinical analysis of an organism requires monitoring of the status of or the changes in condition. As a result of injury or illness or other deleterious biological conditions, the hematocrit or the concentration of hemoglobin in erythrocytes available for oxygen transport to the cells of the organism may be diminished below healthy levels even to the point of critical life sustaining levels. Also, analysis of various types of anemia is vital to continuing successful treatment of a patient, especially in critical care facilities such as emergency rooms, operating rooms, or intensive care units, including neo-natal units. Less traumatic but just as vital, most blood donors must undergo hematocrit testing to assure that their blood to be donated has appropriate hemoglobin levels for later use.

Several types of techniques have been known for the analysis of blood during patient care. Hemoglobin concentrations are measured traditionally using lengthy and complicated procedures which require the preconditioning, i.e., chemical modification or component separation, of a blood sample withdrawn from the body. The traditional methods destroy the blood, preventing its return to the body.

One popular method for the determination of hemoglobin involves (1) lysing the red blood cells by hypotonic shock or sonification, (2) removal of the red blood cell membranes to produce a clear solution, (3) addition of a cyanide ion reagent to normalize or convert the various forms of hemoglobin to a single form hemoglobin (e.g., cyanomet hemoglobin), and (4) spectrophotometric analysis to derive the hemoglobin concentration of the normalized sample.

Because of the complicated chemical procedure for determination of hemoglobin concentration, and

## EP 0 419 223 A2

because of the known direct correlation between hematocrit and hemoglobin concentration, methods for independently determining hematocrit have been developed.

The most common methods for measurement of hematocrit can be divided into two categories: centrifugal attribution in a test tube of specific diameter and Coulter counting.

5 Centrifugal attribution involves centrifuging of blood withdrawn from the body in a tube of specific diameter at pre-selected centrifugal forces and times that serve to separate the blood into two portions. The heavier portion is the agglomeration of erythrocytes in the whole blood. The lighter portion is plasma dominated by water. The ratio of the volume of the erythrocytes to the total volume of the blood sample in the centrifuge tube is the hematocrit.

10 Coulter counting determines hematocrit by physical counting of red blood cells and a determination, through the size of each cell on a cell-by-cell basis, the volume of each. After a predetermined number of blood cells are counted, the hematocrit is determined by the number of red blood cells counted multiplied by the mean volume of the blood cells for a given blood sample.

As may be understood by considering such current methods, considerable manipulation and laboratory analysis is necessary for each individual blood sample drawn from the body of the patient. Whether 15 measuring hematocrit or hemoglobin concentration, the blood sample is withdrawn from the patient and inevitably taken from the immediate vicinity of the patient for analysis using expensive, stationary instrumentations that require preconditioning of the sample in order to analyze it.

Efforts to spectrally analyze blood samples for hematocrit or hemoglobin concentration have been 20 attempted. U.S. Patent 4,243,883 describes a monitor of a flowing stream of blood using a discrete near-infrared wavelength. U.S. Patent 4,745,279 describes a dual path NIR spectral analysis at discrete wavelengths of flowing whole blood. U.S. Patent 4,805,623 describes a NIR spectral method and apparatus using multiple wavelengths to determine the concentration of a dilute component of known identity in comparison with a reference component of known concentration.

25 The near-infrared (NIR) spectral region of electromagnetic radiation, from about 680 nanometers to 2700 nanometers, contains absorbance peaks for the various forms of hemoglobin and water. Prior spectral analytical efforts have focused on the measurement of the diffuse transmission or reflectance of near infrared light through blood samples. However, light scattering in the samples and other properties which interfere with accurate measurement cause variances in the specific spectrum taken. As a result, even using 30 measurements taken with sensitive instrumentation is not satisfactory. Moreover, the choice of specific wavelengths in near-infrared spectra for which whole blood samples may be best monitored is not straightforward due to variances in the broad peaks of water and various forms of hemoglobin in such NIR spectra.

Even with the best monitoring wavelengths being chosen, one must address the variability caused by 35 the effective path length that the transmitted or reflected near-infrared radiation takes between excitation and detection through the blood sampling. This is especially true when the blood being irradiated is constantly changing due to movement of the blood, a dynamic condition for spectral analysis. Prior efforts to employ NIR spectral analysis have either discounted the importance of determining effective path length or required procedures to establish the effective path length prior to completing the spectral analysis. In the 40 former case, reproducible precision suffers; in the latter case, a complicated methodology is employed.

Thus, what is needed is a method for accurately determining through NIR spectral analysis in a dynamic condition a property of a sample of biological matter which is rapid, inexpensive, accurate, precise, and which takes into account such spectroscopic variabilities as effective path length of the reflected or transmitted light or where instrumentation may be using either a continuous measurement of absorbance 45 wavelengths across a NIR spectra or at discrete wavelengths thereof.

#### Summary of the Invention

50 The present invention provides a method for rapidly, inexpensively, and accurately characterizing the properties of matter of biological origin containing water by analyzing the near-infrared spectrum of the biological matter while in a dynamic condition using techniques useful with NIR spectral instrumentation and predicting the properties without sample preconditioning. The techniques seek to minimize the effect of light 55 scattering and use mathematical regression analysis to permit transforming the observed spectrum into a prediction of the property to be analyzed.

The method of the present invention avoids chemical alteration or physical separation of the components in the sample of biological matter. The method also avoids inaccuracies caused by irrelevant

## EP 0 419 223 A2

variations in samples and instrumental noise in measurement techniques.

The method of the present invention is founded on the principle that the biological matter may be considered to consist of essentially two compartments: one compartment which has a proportionally different (larger or smaller) amount of water than the other compartment related to or having the property to be analyzed. The present invention is also founded on the principle that identification of the volume or weight fraction or concentration of water in the biological matter will serve as the basis for calculation of the property to be analyzed. The method of the present invention is further founded on the principle that the establishment of a training set of the combination of NIR spectra of several samples of the biological matter and the independent quantification of the property to be analyzed in each sample provides a source of mathematical comparison for accurately predicting the property to be analyzed in an unknown additional sample by using such mathematical comparison.

When the biological matter is whole blood, prediction of the hematocrit or hemoglobin concentration is achieved by obtaining near-infrared spectra of a statistically sufficient number of samples of whole blood to establish a training set for mathematical comparisons against individual additional unknown samples of other whole blood. Further, the property to be analyzed in the whole blood, e.g., hematocrit or hemoglobin concentration, is independently quantified by using an independent known technique: lysing and chemical alteration for hemoglobin and Coulter counting or centrifuging for hematocrit.

Having established a training set of NIR spectra and independently quantified the hematocrit or hemoglobin concentration in each sample in the training set, the nature of the inter-relationship between the hematocrit or hemoglobin and the water content is statistically correlated to establish the source of comparison when predicting unknown samples.

To minimize variability when establishing the training set and when predicting the properties of the compartment being analyzed in the unknown sample, a pre-processing technique is employed.

One useful pre-processing technique is disclosed in European Patent Publication based on an application claiming priority from U.S. Patent Application Serial Number 07/408,747. That technique is a multiple derivative transformation of the training set spectra and the unknown sample's spectrum to minimize the effect of light scattering and other instrumental noise on the various spectra, in order to allow a mathematical correlation using the multiple derivative of the spectral intensity at a single wavelength to accurately predict the property of the compartment being analyzed in the unknown sample.

A different and useful type of pre-processing technique is disclosed in European Patent Publication based on an application claiming priority from U.S. Patent Application serial Number 07/408,746. That technique is a ratio pre-processing technique which applies a ratio of an absorbance peak of the water content in the biological matter to another absorbance measuring point in order to minimize variations due to sampling techniques and instrumentation factors. This allows the accurate mathematical correlation to predict the property of the compartment being analyzed in the unknown sample.

In the case of hematocrit or hemoglobin concentration determinations, through mathematical regression analysis, it has been found that use of the absorbance peak of water appearing in NIR spectra in the range of from about 1150 to about 1190 nanometers (nm) provides an accurate and reproducible peak for multiple derivative transformation pre-processing techniques, notwithstanding a known decrease in detector efficiency using silicon detectors in this range of wavelengths. This peak of absorbance of water in the 1150-1190 nm range is largely isolated from the absorbance of hemoglobin either in its oxygenated state or in its deoxygenated state. The absorbance peak of water in this region is primarily the result of simultaneous excitation of the symmetric O-H stretch, the O-H bending mode, and the antisymmetric O-H stretch of the water molecule, whether existing in the biological matter as free water, bound to other molecules, or other forms.

While the peak of absorbance of water in the 1150-1190 nm range may be largely isolated from the absorbance of hemoglobin, it is not totally isolated. Indeed, it is preferred in the present invention to distinguish between the two principal forms of the hemoglobin component in whole blood, oxyhemoglobin and deoxyhemoglobin, and add that independent variable to the regression analysis which both establishes the training set and predicts the unknown sample's hematocrit or hemoglobin concentration.

Gathering the training set spectral data for the samples of the biological matter depends on the type of instrumentation to be employed. To establish the training set according to the present invention, the biological matter is diverted from the body of the organism and returned.

For purposes of full disclosure, a different and useful method of gathering data employing a static condition of spectral analysis is disclosed in either European Patent Publication or European Patent Publication based on applications claiming priority from U.S. Patent Application Serial Number 07/408,747 or U.S. Patent Application Serial Number 07/408,746, respectively. In those instances the biological matter may be withdrawn from the body of the organism. Additionally, the biological matter may

## EP 0 419 223 A2

be measured within the body of the organism. However, to provide the independent quantification of the property to be analyzed from the training set samples, a sample of the biological matter must be withdrawn from the organism and often cannot be returned to the organism because of chemical alteration or physical separation of the compartment in the matter.

5 One embodiment of diversion and return of the biological matter to the patient is an extracorporeal loop described herein.

Gathering the unknown sample spectral data for analysis also depends on the type of instrumentation to be employed. The unknown sample may be diverted from the body of the organism for spectral detection or measurement and returned to the body, or the unknown sample may be analyzed in vivo. One  
10 embodiment of diversion and return of the biological matter to the patient is the extracorporeal loop described herein.

Processing and instrumentation variabilities are dependent upon the method by which the training set is established and the method by which the unknown samples are analyzed. In the present invention, the biological fluid is moving when being spectrally analyzed, a dynamic condition.

15 When the biological fluid is whole blood and the hematocrit or the concentration of hemoglobin is desired, the whole blood, either moving from the body through a optical path before returning or moving in the body, is spectrally analyzed in a dynamic condition either using diffuse transmission detection or reflectance detection as appropriate.

Because of the use of the appropriate pre-processing technique, variations due to sampling techniques  
20 of biological matter in a dynamic condition and instrumentation factors such as effective path length are minimized.

The NIR spectrum of the unknown sample is obtained from either continuous or discrete wavelength measuring instrumentation. After the spectrum is obtained and subjected to the appropriate pre-processing, the property of interest may be predicted by a mathematical correlation to the training set spectra.

25 In the case of the measurement of hematocrit or hemoglobin concentration in an unknown sample of whole blood, after the NIR spectrum of the unknown sample is observed and subjected to pre-processing, application of mathematical techniques comparing the training set spectral data for the hematocrit or the hemoglobin concentration with the unknown sample's spectra allows prediction of the hematocrit or the hemoglobin concentration in the unknown sample.

30 For an additional appreciation of the scope of the present invention, a more detailed description of the invention follows, with reference to the drawings.

#### Brief Description of the Drawings

35 FIG. 1 is a schematic block diagram of the instrumentation useful in a method carried out in accordance with the present invention.

FIG. 2 is a schematic flow chart of the methods to mathematically minimize variability of spectral data using multiple derivative transformation techniques and establish the mathematical correlation between  
40 known samples and the training set spectra, in order to permit the predicting of the property of interest in an unknown sample by comparison with the mathematical correlation.

FIG. 3 is a schematic flow chart of the methods to mathematically minimize variability of spectral data using ratioing techniques and establish the mathematical correlation between known samples and the training set spectra, in order to permit the predicting of the property of interest in an unknown sample by  
45 comparison with the mathematical correlation.

FIG. 4 is a graphic representation of typical whole blood spectra detected in a dynamic condition indicating the effects of typical light scattering variances and other instrumental noise variances.

FIG. 5 is a graphic representation of the same whole blood spectra as in FIG. 4 after the application of the multiple derivative transformation to minimize the effects of typical light scattering variances and  
50 other instrumental noise variances.

FIG. 6 is a correlation plot of correlation coefficient versus wavelength for hemoglobin after the spectral data were second derivative pre-processed and regression analysis of the spectral data was performed against hemoglobin.

FIG. 7 is a correlation map of correlation coefficient squared versus wavelength for hemoglobin after ratio  
55 pre-processing and regression analysis of the spectral data was performed against hemoglobin.

FIG. 8 is a graph showing the accuracy of prediction of hematocrit after multiple derivative transformation pre-processing compared with actual hematocrit values determined by prior art methods.

FIG. 9 is a graph showing the accuracy of prediction of hematocrit after ratioing pre-processing

## EP 0 419 223 A2

compared with actual hematocrit values determined by prior art methods.

FIG. 10 is a schematic flow chart, similar to FIG. 2, of another method of the present invention to mathematically minimize variability of spectral data using multiple derivative transformation techniques and adjustment for the different forms of hemoglobin.

5 FIG. 11 is a schematic flow chart, similar to FIG. 2, of another method of the present invention to mathematically minimize variability of spectral data using ratioing techniques and adjustment for the different forms of hemoglobin in the whole blood.

FIG. 12 is a graph showing the accuracy of prediction of hematocrit after multiple derivative transformation pre-processing and adjusting for the different forms of hemoglobin present in the whole blood, compared with actual hematocrit values determined by prior art methods.

10 FIG. 13 is a graph showing the accuracy of prediction of hematocrit after ratioing pre-processing and adjusting for the different forms of hemoglobin present in the whole blood, compared with actual hematocrit values determined by prior art methods.

FIG. 14 is a schematic depiction of the components of the extracorporeal blood loop of the present invention.

### Embodiments of the Invention

One embodiment of the present invention is the analysis of hematocrit in whole blood. Another  
20 embodiment of the present invention is the analysis of hemoglobin concentration in whole blood. There are occasions when either analysis may be preferred. But generally, it is recognized that the determination of hematocrit is an excellent correlation to the concentration of hemoglobin in whole blood. However for versatility of the system, it should be recognized that one or more methods of independent quantification of the property to be analyzed may be used to provide alternative clinical diagnosis of the condition of the patient.

It should also be recognized that the property of the biological matter to be analyzed must have some correlation either positively or negatively with the water content in order to develop a mathematical correlation therefor in accordance with the present invention. That may not preclude the presence of other components in de minimus volume fractions or concentrations. For example, in whole blood, the presence  
30 of white blood cells, platelets, hydrocarbonaceous lipids, and the like are not present in sufficient quantity at the desired level of precision to destroy the validity of the mathematical correlation found. However, as described below, the determination of the oxygen saturation in the whole blood may distinguish between oxyhemoglobin and deoxyhemoglobin, in order to predict the property of interest with greater accuracy.

### SPECTROSCOPIC INSTRUMENTATION

FIG. 1 identifies the schematic block diagram of spectral instrumentation useful in establishing the  
40 training set initially and thereafter predicting the property of the compartment to be analyzed in one or more unknown additional samples.

FIG. 1 illustrates a typical instrumentation system available which can be used for obtaining the near infrared spectrum of a biological fluid, such as whole blood. Specifically, FIG. 1 identifies a Model 6250 spectrophotometer manufactured by Near Infrared Systems of Silver Spring, Maryland, formerly known as  
45 Model 6250 made by Pacific Scientific. The radiation from a tungsten lamp 100 is concentrated by a reflector 101 and lens 102 on the entrance slit 103 and thereafter passed through an order sorting filter 104 before illuminating a concave holographic grating 105 to disperse the radiation from the tungsten lamp 100 onto the sample 113 in a dynamic condition in an optical blood loop or in the body of the organism. The grating 105 is where the wavelength dispersion occurs. The grating is scanned through the desired  
50 wavelength range, typically 680 to 1235 nanometers, by the rotating cam bearing 106, which is coupled to the grating by linkage assembly 107. The selected wavelength passes through exit slit 108 and is guided through the cell 113 through which the sample is moving in direction F, by mirror 109, iris 111, and lenses 110 and 112. After passing through the sample, the remaining radiation is converted to an electrical signal by detector 114.

55 Other types of instrumentation are also acceptable for use with the methods of the present invention. Monochromators such as Model HR 320 available from Instruments S.A. are useful. Polychromators such as the Chemspec Model 100S available from American Holograph or Model JY320 also available from Instruments S.A. may be used to gather the spectral data to establish the training set.

## EP 0 419 223 A2

Detection means may employ either diffuse transmittance detection devices or reflectance devices available commercially. The Model 6250 spectrophotometer may be configured to detect either diffuse transmittance or diffuse reflectance. Depending on factors such as cost, wavelength range desired, and the like, the detector 114 may be a silicon detector, a gallium arsenide detector, a lead sulfide detector, an indium gallium arsenide detector, a selenium detector or a germanium detector.

Whichever detector is chosen, it is preferred to be consistent in the usage of same detection means for establishing the training set spectra and for measuring the unknown sample's spectrum.

Alternately, polychromatic analyzers using a reversed beam geometry may be used to disperse the transmitted or reflected light into its spectral components and photodiode arrays may be used to detect or measure the dispersed light at different positions along the output spectral plane.

Other types of array detectors include charge coupled devices, charge injection devices, silicon target vidicons, and the like. Desirably, the polychromatic analyzer should include an entrance slit that defines the bandwidth of light which is consistent with the spectral resolution desired. One commercially available photodiode array useful with the present invention is Model 1024S photodiode array available from Reticon, Inc., which consists of 1024 diodes of 25 micron width and 2.5 millimeters height. That photodiode array may be used in a complete spectral detection system such as Model ST120 available from Princeton Instruments.

One can also use interference filters as spectroanalyzers, for example, by passing a series of discrete wavelength interference filters one at a time before a suitable detector. It is also possible to use interferometers or a Hadamard transform spectrometer to analyze the diffuse light.

The above detection means are based on detection of spectra from a broad band light source. However, if narrow band sources of NIR light are to be used, such as tungsten lamps with interference filters, light emitting diodes, or laser (either a single tunable laser or multiple lasers at fixed frequencies), other detection techniques may be used. For example, the input signal can be multiplexed either in time, (to sequence each wavelength), or in wavelength (using sequences of multiple wavelengths), and thereafter modulated and the collected signals demodulated and demultiplexed to provide individual wavelength signals without the need for optical filtering.

Regardless of the spectroscopic instrumentation selected, it is preferred to use a computer connected to the instrument to receive the spectral data, perform the analysis described below, and provide a printout or readout of the value of the property predicted. When using spectrometric instruments such as the Model 6250 spectrometer described above, a personal computer such as a "PS/2" Model 50 computer from IBM of Boca Raton, Florida is used and preferred.

#### MULTIPLE DERIVATIVE PRE-PROCESSING TECHNIQUE AFTER DYNAMIC CONDITION SPECTRAL DATA GATHERING

FIG. 2 is a schematic flow chart of the method of the present invention using for pre-processing the multiple derivative transformation pre-processing technique disclosed in U.S. Patent Application Serial Number 07/408,747, which pre-processing is employed to minimize sample and instrumentation variability. The regression analysis of the method identifies the nature of the mathematical correlation between the property to be analyzed in the first compartment and the water content in the biological matter, in order to predict the property of the compartment to be analyzed in an unknown sample.

The schematic flow of the processing steps involved in determining the property of interest in the biological matter, such as hematocrit or hemoglobin concentration, can be broadly divided into two parts: steps 120 to 128 which comprise the training phase of the analysis and steps 129 to 133 which comprise the prediction of the property of an unknown sample.

The training or calibration development phase consists of observing a series of blood samples 120 by diverting the samples from one or more animals of the same species through a blood loop or by otherwise observing the samples in the organisms. Additionally, for the independent quantification of property of interest, samples are obtained by withdrawing blood, step 121, from each of the animals participating in step 120.

The samples of steps 120 and 121 are analyzed on two parallel paths.

The first path consists of independent quantification of the property of interest, step 122. It is important that the independent quantification be done accurately. The accuracy of the method of the present invention is dependent upon the accuracy of the independent quantification step 122 because validation of the mathematical correlation is based on the independently quantified value of the property of interest.

## EP 0 419 223 A2

The second path consists of irradiating the samples with infrared light and detecting the near infrared spectrum for each sample, step 123, and then computing the second derivative of the spectra, step 124. It should be understood that reference to detecting the near infrared spectrum involves both the measurement of diffusely transmitted or reflected spectrum and the transformation of that spectrum to an absorbance spectrum. The transformation is based on having taken a spectrum of the cell containing only air for calibration purposes.

When the near infrared spectrum has been detected on a Near Infrared Systems Model 6250 spectrophotometer, the near infrared spectrum from 680 to 1235 nanometers consists of 700 individual absorbance measurements. The second derivative transformation preprocessing step computes less than the total 700 measurements because some transformations are not available at the edges of the spectra. When using software such as "Near Infrared Spectral Analysis" commercially available from Pacific Scientific, now known as Near Infrared Systems of Silver Spring, Maryland, one may compute an approximated derivative by using finite difference approximations. Different approximations may yield different derivative spectra and different transformation equations. In such software, different approximations may be adjusted according to segment of the spectrum being measured and the gap between segments being measured. Using different derivative approximations may result in a different set of regression coefficients that may affect the accuracy or precision of the prediction of the property being analyzed. It is therefore prudent to evaluate a wide range of segments and gaps in order to ascertain which selection is best for the particular analysis contemplated.

The preprocessed spectra for the set of training samples subjected to second derivative transformation, step 124, are correlated with the values obtained during the independent quantification step 122 by using a mathematical regression technique, step 125, such as linear regression. The second derivative value providing the best correlation of calculated value to actual value is generally the wavelength chosen for the mathematical correlation.

One of the outputs of this regression step is a correlation plot, step 126, which graphically shows the wavelengths of the spectrum where the highest correlation is found. The best transformed wavelength in the water band region of 1150 to 1190 nm, step 127, is selected by identifying the peak of optimum correlation. The regression coefficients corresponding to the selected wavelength are saved, step 128, for future application to the analysis of individual samples to predict the property of interest.

The steps 129 to 133 in FIG. 2 show the procedure to be followed for predicting hematocrit (abbreviated as HCT in FIG. 2) or hemoglobin (abbreviated as HB in FIG. 2) concentration in an individual unknown sample. A blood sample of unknown hematocrit or hemoglobin concentration, step 129, is observed by viewing the blood in an extracorporeal blood loop or in the organism, and the near infrared spectrum of this sample is detected or measured, step 130.

While the near infrared spectrum of additional unknown samples may also be detected on exactly the same instrument as the training samples were detected and from which the training set is prepared, it is also acceptable to use a simpler instrument which will provide the absorbance at only the three minimal wavelengths necessary to compute a second derivative transformation of the best wavelength.

The second derivative intensity for the best wavelength determined in step 127 is computed for the unknown sample, step 131. Then the regression coefficients contained in the mathematical correlation, determined during the training procedure and saved in step 128, are applied to the second derivative wavelength obtained for the additional individual unknown blood sample 132, in order to yield the predicted hematocrit or hemoglobin concentration, step 133.

The pre-processing technique of multiple derivative transformation serves to eliminate the variances of spectral data caused by scatter in each of the various samples of both the training set and each unknown sample. This scatter would otherwise disrupt the accuracy of the detection of the training set spectra and its ability to predict the property of the unknown sample.

If the near infrared spectrum consists of N individual wavelengths, computing the second derivative transformation provides N spectral features less the loss of the features at the edges of the spectrum. In FIG. 2, such computation is shown at step 124. The best wavelength must be chosen from the myriad of N transformed wavelengths using regression mathematical techniques, as is shown in FIG. 2 at step 125, depicted in a correlation plot at step 126, and selected at step 127 for use to determine the best possible regression coefficients in step 129 and for use with each unknown sample in step 132.

Any of a number of regression techniques; such as, linear regression, multiple linear regression, stepwise regression, partial least squares regression, or principal component regression can be used to develop a statistical correlation between the ratio spectral features and the variable of the property being quantified. Such regression techniques are available by reference to such literature as Draper and Smith, Applied Regression Analysis, Wiley and Sons, New York, 1982 and Geladi and Kowalski, Analytica Chimica

## EP 0 419 223 A2

Acta, Volume 185, pp 1-17 and 19-32, 1986.

In order to determine the best wavelength for a given application, regression models are computed against all of the possible N transformed wavelengths.

Each regression model is evaluated by using an accepted statistical measure. For example, one useful  
5 measure is the simple correlation coefficient computed from the actual hematocrit value obtained from the independent quantification and the predicted hematocrit value obtained from the regression model, as is shown in FIG. 2 at step 127.

A correlation plot can be constructed to visually show which wavelength involving the absorbance of water provides the highest correlation, as is shown in FIG. 2 at step 127. A representative correlation plot  
10 for hemoglobin appears as FIG. 6. It is important to consider both high correlation and also the sensitivity of the correlation obtained to measure small changes in the actual wavelengths.

## RATIO PRE-PROCESSING TECHNIQUE AFTER DYNAMIC CONDITION SPECTRAL DATA GATHERING

15

FIG. 3 is a schematic flow chart of the method of the present invention using for pre-processing the ratio pre-processing technique described herein and also disclosed in U.S. Patent Application Serial Number 07/408,746, which pre-processing is employed to minimize sample and instrumentation variability.  
20 The regression analysis of the method identifies the nature of the mathematical correlation between the property to be analyzed in the first compartment and the water content in the biological matter, in order to predict the property to be analyzed in an unknown sample.

The schematic flow of the processing steps involved in determining the property of interest in the biological matter, such as hematocrit or hemoglobin concentration, can also be broadly divided into two  
25 parts: steps 220 to 228 which comprise the training phase of the analysis and steps 229 to 233 which comprise the prediction of the property of an unknown sample.

The training or calibration development phase consists of observing a series of blood samples 220 by diverting the samples of one or more animals of the same species through a blood loop or by otherwise observing the samples in the organisms. Additionally, for the independent quantification of property of  
30 interest, samples are obtained by withdrawing blood, step 221, from each of the animals participating in step 220.

The samples of steps 220 and 221 are analyzed on two parallel paths.

The first path consists of independent quantification of the property of interest, step 222. It is important that the independent quantification be done accurately. The accuracy of the method of the present invention  
35 is dependent upon the accuracy of the independent quantification step 222 because validation of the mathematical correlation is based on the independently quantified value of the property of interest.

The second path consists of irradiating the samples with infrared light and detecting the near infrared spectrum for each sample, step 223, and then computing all possible ratios of two wavelengths in the spectrum, step 224.

When the near infrared spectrum has been detected on a Near Infrared Systems model 6250 spectrophotometer, the near infrared spectrum from 680 to 1235 nanometers consists of 700 individual absorbance measurements. The preprocessing step of computing all possible ratios of two wavelengths expands the 700 point spectrum into 700 \* 700 or 490,000 ratio pairs. Since near infrared spectra consist of broad, slowly changing absorbance bands, computing the ratio terms using every fifth data point, 140 point  
45 spectrum, results in equivalent performance with a significant decrease in the overall computation requirement, 140 \* 140 or 19,600 ratio terms.

The preprocessed spectra for the set of training samples consisting of the calculated ratios, step 224, are correlated with the values obtained during the independent quantification step 222 by using a mathematical regression technique, step 225, such as linear regression. The pair providing the best  
50 correlation of calculated values to actual values is generally the pair of wavelengths chosen for the ratio in the mathematical correlation.

One of the outputs of this regression step is a correlation map, step 226, which graphically shows the regions of the spectrum where the most useful ratio pairs are found. The best ratio pair, step 227, is selected by identifying a region of high correlation which is also independent of small changes in the actual  
55 wavelength selected. The regression coefficients corresponding to the selected ratio pair are saved, step 228, for future application to the analysis of individual samples of unknown analyte content.

The steps 229 to 233 in FIG. 3 show the procedure to be followed for predicting hematocrit (abbreviated as HCT in FIG. 3) or hemoglobin (abbreviated as HB in FIG. 3) concentration in an individual



## EP 0 419 223 A2

unknown sample. A blood sample of unknown hematocrit or hemoglobin concentration, step 229, is observed in a dynamic condition and the near infrared spectrum of this sample is detected or measured, step 230.

5 While the near infrared spectrum of additional unknown samples may also be detected on exactly the same instrument as the training samples were measured and from which the training set spectra is prepared, it is also acceptable to use a simpler instrument which will provide the absorbance at only the two wavelengths selected to form the best ratio pair.

The ratio of the absorbance readings for the selected pair of wavelengths determined in step 227 is computed for the unknown sample, step 231. Then the regression coefficients contained in the mathematical correlation, determined during the training procedure and saved in step 228, are applied to the ratio  
10 obtained for the additional individual unknown blood sample 232, in order to yield the predicted hematocrit or hemoglobin concentration, step 233.

The ratio pre-processing technique serves to eliminate the variances of spectral data caused by scatter or other multiplicative errors in each of the various samples of both the training set and each unknown  
15 sample. This scatter would otherwise disrupt the accuracy of the detection of the training set spectra and its ability to predict the property in the unknown sample. Because both wavelengths in the selected best pair of wavelengths used in the ratio experience the same path length, variations in the effective path length due to scatter are minimized.

If the near infrared spectrum consists of N individual wavelengths, computing all possible ratios of each pair of wavelengths provides N\*N new spectral features. In FIG. 3, such computation of all possible ratios is shown at step 224. The best possible ratio pair of wavelengths must be distilled from the myriad of combinations using regression mathematical techniques, as is shown in FIG. 3, at step 225, depicted in a correlation map at step 226, and selected at step 227 for the use to determine the best possible regression coefficients in step 228 and for use with each unknown sample in step 231.  
20

Any of a number of regression techniques; such as, linear regression, multiple linear regression, stepwise regression, partial least squares regression, or principal component regression can be used to develop a statistical correlation between the ratio spectral features and the variable of the analyte being quantified. Such regression techniques are available by reference to such literature as Draper and Smith and Geladi and Kowalski publications described above for use in multiple derivative transformation. In order  
25 to determine the best ratio for a given application, regression models are computed against all possible ratio pairs of wavelengths.

Each regression model is evaluated by using an accepted statistical measure. For example, one useful measure is the simple correlation coefficient computed from the actual hematocrit value obtained from the independent quantification and the predicted hematocrit value obtained from the regression model, as is  
30 shown in FIG. 3 at step 228.

A correlation map can be constructed to visually show which wavelength ratios provide the highest correlation, as is shown in FIG. 3, at step 226. A representative correlation map for hemoglobin appears as FIG. 7. It is important to consider both high correlation and also the sensitivity of the correlation obtained to measure small changes in the actual wavelengths. The best overall ratio is found by selecting the pair of  
35 wavelengths which provide high correlation and which occur in a reasonably flat region of the correlation map.

## ANALYSIS AND VALIDATION

45

Use of the spectral analytical instrumentation described above and depicted in FIG. 1 and either of the mathematical methods described above and depicted in FIGS. 2 and 3 permit the analysis of the property of interest in the biological matter which contains water, so long as it is possible to develop a mathematical  
40 correlation between that property and water when establishing the training set through independent quantification of the property, spectra of the samples and use of the appropriate pre-processing techniques to minimize variability.

The determination of the mathematical correlation or model is founded on the linear functional relationship of the multiple linear regression equation:  $B_0 + B_1 (A_1) + B_2 (A_2) + \dots B_n (A_n) = C$  where  $B_0$  is the intercept,  $B_n$  is the regression coefficient for the nth independent variable,  $A_n$  is the nth independent variable and C is the value of the property of interest to be analyzed. Solving this equation depends upon  
45 the determination of regression coefficient(s) including the intercept and providing the values of the independent variable(s).

## EP 0 419 223 A2

When the linear functional relationship is less complex, the equation is more often expressed as the linear regression equation:  $Y = mx + b$ , where  $Y$  is the value of the property of interest to be analyzed,  $m$  is the regression coefficient indicating the slope of the line,  $b$  is the intercept of the line and  $x$  is the single independent variable. Thus, the mathematical correlation endeavors to yield a linear relationship between the single independent variable, which is the multiple derivative transformed intensity or the ratio of the two best absorbance pairs, and the property of interest to be measured.

The linear functional relationship is more complex and involves more than one independent variable when the effect of oxygen saturation is used to adjust the mathematical correlation of hematocrit or hemoglobin concentration to the water content in whole blood. Then, the equation is expressed as a multiple linear regression equation:  $C = B_0 + B_1 (A_1) + B_2 (A_2)$ , where  $C$  is the hematocrit or hemoglobin concentration;  $B_0$  is the intercept;  $B_1$  is the regression coefficient for the percent oxygen saturation;  $A_1$  is the percent oxygen saturation;  $B_2$  is the regression coefficient of the independent variable determined from either the multiple derivative transformation or the ratioing preprocessing.

Once the mathematical correlation is established, it is validated. The accuracy in formation and performance is reviewed to assure reproducibility. The accuracy and precision of the mathematical correlation can be validated by physical interpretation of the selected spectral features or using additional samples analyzed by independent quantification, step 122 of FIG. 2 or step 222 of FIG. 3, and then subjecting those samples to steps 129-133 of FIG. 2 or steps 229-233 of FIG. 3, as if the samples were unknown. Statistical methods may then be used to compare the value of the predicted property, step 133 or step 233, and the value determined by independent quantification, step 122 or step 222, to confirm reproducibility.

Standard error of calibration measures precision of formation of the model of the training set spectra, i.e., how well the regression analysis performs with the data used to construct the training set. The standard error of calibration (SEC) can be calculated from the following equation:

$$SEC = \left[ \frac{1}{N_T - n - 1} \sum_{i=1}^{N_T} (C_i - c_i)^2 \right]^{1/2}$$

where  $N$  is the number of training samples,  $n$  is the number of absorbance terms in the regression technique employed, where  $c_i$  is the hematocrit value of the  $i$ th sample as calculated during linear regression and  $C_i$  is the hematocrit value of the  $i$ th sample as independently determined. The smaller the SEC, the more precise the model mathematical correlation has been formed.

More importantly, the standard error of prediction (SEP) measures the assurance of reproducible performance, i.e., a test to identify quantitatively the accuracy and precision of the prediction results obtained using the method of the present invention with the actual value for the property determined by independent quantification using known and accepted techniques and may be used in conjunction with a confidence limit to quantitatively express the accuracy of the prediction of the property being analyzed. Mathematically, the standard error of prediction can be calculated from the following equation:

$$SEP = \left[ \frac{1}{N_p - n - 1} \sum_{i=1}^{N_p} (C_i - c_i)^2 \right]^{1/2}$$

where  $N$  is the number of validation samples,  $C_i$  is the independently quantified value for the  $i$ th validation sample,  $c_i$  is the value for the  $i$ th validation sample obtained using the mathematical correlation of step 131. Also, the smaller the SEP, the more accurate and precise the prediction.

Bias measures the extent of deviation of all points within a given data set in the solved mathematical equation from the line of exact correlation between predicted and actual values. Qualitatively, a low bias indicates the presence of a robustness of the training set spectra to tolerate possible error. In other words, the robustness of the training set sampling anticipates the variety of sampling possibilities for the unknown sample and minimizes its effect.

## EP 0 419 223 A2

## INDEPENDENT VARIABLE BASED ON OXYGEN SATURATION OF HEMOGLOBIN

As stated above with reference to the flow charts depicted in FIGS. 2 and 3, the regression analysis  
5 may employ multiple variables according to the equations described above.

One multiple variable of assistance to the prediction of the property of interest is the percentage oxygen  
in the hemoglobin of whole blood, which distinguishes the hemoglobin between its oxy and deoxy forms.  
Because oxy and deoxy hemoglobin have different spectra, including in the region of 1150-1190 nm, the  
assessment of the relative contributions of both forms of hemoglobin, or a value proportional to their relative  
10 contributions, allows the adjustment of the mathematical correlation being developed for the prediction of  
hematocrit or hemoglobin concentration.

FIGS. 10 and 11 depict the schematic flow charts, similar to FIGS. 2 and 3, respectively. Reference  
numbers 320-333 in FIG. 10 depicts the same steps as reference numbers 120-133 in FIG. 2. Reference  
numbers 420-433 in FIG. 11 depicts the same steps as reference numbers 220-233 in FIG. 3. FIGS. 10 and  
15 11 add the steps in the method to adjust the mathematical correlation and the prediction to account for  
percent oxygen saturation in the whole blood. As may be seen in FIG. 10, measurement of oxygen  
saturation or a value proportional to oxygen saturation, step 334, is added to assist in performing the linear  
regression, step 325, and step 330 is modified to include the measurement of the oxygen saturation or a  
value proportional to oxygen saturation in the unknown sample. Likewise, measurement of oxygen saturation  
20 or a value proportional to oxygen saturation, step 434, is added to assist in performing the linear regression,  
step 425, and step 430 is modified to include the measurement of the oxygen saturation or a value  
proportional to oxygen saturation in the unknown sample. These alterations provide the adjustment of the  
independent variable, percent oxygen saturation or a value proportional to oxygen saturation, to the other  
independent variable, the multiple derivative transformed spectral intensity at the best wavelength or the  
25 best ratio.

The effect of percent oxygen saturation or a value proportional to oxygen saturation as an independent  
variable is linear throughout the percent oxygen saturation range. However, as percent oxygen saturation  
approaches 100 percent, the magnitude of the adjustment provided by this independent variable is  
progressively smaller, such that it becomes within the level of accuracy of the independent quantification  
30 itself.

Thus, for fully oxygenated patients, the use of the percent oxygen saturation independent variable in the  
mathematical correlation is optional. For less than fully oxygenated patients, the use of the percent oxygen  
saturation independent variable in the mathematical correlation is preferred. In emergency conditions,  
whether it is known if the patient is fully oxygenated is problematic. Therefore, for analysis of hematocrit or  
35 hemoglobin concentration, it is generally preferred to include percent oxygen saturation as an independent  
variable in the mathematical correlation.

Instruments to measure oxygen saturation of the hemoglobin concentration at the same time as the  
spectrum of whole blood is analyzed includes such commercially available instrumentation as a co-  
oximeter, a pulse oximeter, or other device which measures the oxygen saturation known to those skilled in  
40 the art. Co-oximetry typically involves measurement of oxygen saturation in a static condition. However, the  
art has progressed to measuring oxygen saturation in flowing blood such as that shown in U.S. Patent  
4,745,279.

Another method of measuring the second independent variable as a value proportional to percent  
oxygen saturation for purposes of the regression analysis depicted in FIG. 10 at 334 and 330, respectively  
45 and FIG. 11 at 434 and 430, respectively, is to employ a ratio of absorbances at two wavelengths. In other  
words, the value proportional to percent oxygen saturation is the ratio of the absorbances of two  
wavelengths where the ratio of the extinction coefficients for oxyhemoglobin and deoxyhemoglobin at one  
wavelength is different than that ratio at the second wavelength. Desirably, the ratio uses the absorbance of  
a wavelength where the extinction coefficients of oxy and deoxy hemoglobin are different, (for example at  
50 from about 680 nm to 720 nm), to the absorbance of a wavelength where the extinction coefficients of oxy  
and deoxy hemoglobins are the same, the isosbestic point. Use of the ratio of this spectral data obviates  
the need for additional oxygen saturation instrumentation.

The comparison of predicted vs. actual hematocrit or hemoglobin concentration may be graphed when  
the percent oxygen saturation is included as an independent variable. FIG. 12 shows a graph of predicted  
55 hematocrit against actual hematocrit. A comparison of FIG. 8 and FIG. 12 shows how the multiple  
independent variable mathematical correlation is generally more accurate.

Inclusion of the second variable in the regression equation serves to minimize even further any effects  
of oxygen saturation in the hemoglobin on the absorbance of the spectra at 1150-1190 nm. Thus, the

## EP 0 419 223 A2

development of a mathematical correlation which includes oxygen saturation as an independent variable enhances rather than substitutes for the method of the present invention to determine a property of interest based on its relationship to the water content in the whole blood.

5

## EXTRACORPOREAL BLOOD LOOP A DYNAMIC CONDITION

An embodiment of the analysis of a property of interest in a biological fluid in a dynamic condition  
10 employs an extracorporeal blood loop. This blood loop permits "real time" monitoring of the changes in the values of the property of interest in whole blood.

When treating a patient during an operation such as open-heart surgery, a blood loop is used for oxygenation of the blood and to maintain adequate circulation. Adaptation of the equipment such as that described in FIG. 1 permits the analysis of hematocrit and hemoglobin concentration according to the  
15 methods of the present invention while the blood is moving from the body of the patient and being returned to the body of the patient. FIG. 14 identifies schematically the type of blood loop of the present invention using reference numerals while the other equipment necessary for the experiments described in the examples are identified by reference letters.

Referring to FIG. 14, the loop 500 is formed by connecting flow through cell 510 in the spectrometer S,  
20 also seen in FIG. 1 as item 113, tubing, generally 520, and valves, generally 530. The loop 500 may be separately configured to the patient P or may form a subloop to the loop already established for the patient P in the operative environment.

Loop 500 includes the following components interconnected: diversion section tubing 521 connected between the patient's blood vessel (not shown) and valve 532, diversion section tubing 522 between the  
25 valve 532 and flow through cell 510, return section tubing 523 between the flow through cell 510 and valve 534, return section tubing 524 between valves 534 and 536, return section tubing 525 between valve 536 and another blood vessel (not shown) of the patient P, and a bypass tubing section 526 between valves 532 and 536.

The tubing, generally 520, and the valves, generally 530, must be made from materials which are  
30 biocompatible with the patient's biological fluid and strong enough to withstand use of flowing pressurized fluid therethrough. A leak in the loop 500 could be traumatic for the patient P.

Preferred commercially available materials for the tubing 520 are "TYGON" brand plastic tubing available from Norton Performance Plastics of Akron, Ohio.

Preferred commercially available valves are three-way stopcock type valves marketed under the  
35 trademark "INTRALOK" from Abbott Sorenson Research of Salt Lake City, Utah.

The flow through cell 510 must be made of a transparent material used in spectrophotometric instrumentation, such as quartz plate glass, and geometrically configured and constructed in a manner to minimize the stagnation of the biological fluid in that portion of the cell irradiated with the near infrared light. Glassblowers skilled in the art are capable of configuring the cell 510, which preferably has an oval shape  
40 with opposing ports at the perimeters of sharper curvatures.

The loop 500 has a biological fluid flow in the direction of arrow F1 from the patient P through diversion section comprising tubing 521 and 522 and in the direction of arrow F2 to the patient through tubing 523, 524, and 525.

Manipulation of valves 532 and 536 allow the control of the amount of biological fluid flowing through  
45 cell 510. It is desired that adequate biological fluid flow through cell 510 during spectral detection. However, if it is desired to entirely bypass cell 510, valves 532 and 536 may be opened in a way to direct all fluid flow through section 526.

Valve 534 is adjacent the emergence of the tubing 523 from the cell 510 in order that any independent quantification needed or desired may be performed in the loop as closely as possible to the location of the  
50 spectral irradiation and detection in the cell 510.

Use of loop 500 may be combined with any spectrometric instrumentation described above, although the use of a spectrometer such as a Model 6250 spectrometer, with a computer such as a personal computer, described above is preferred.

Further, the spectra data may be gathered in conjunction with an extracorporeal blood gas sensor  
55 (EBGS) sold by Cardiovascular Devices, Inc. of Irvine, California.

Through the use of real time monitoring of the spectral data and use of the mathematical correlation obtained according to the methods of the present invention, hematocrit or hemoglobin concentration may be monitored nearly instantaneously, permitting the health care practitioner to treat the patient without delay.

## EP 0 419 223 A2

The extracorporeal loop 500 may be used in routine dialysis procedures as part of the dialysis blood loop to monitor the water content of the blood and other properties of interest. Another use of the extracorporeal loop 500 is in critical cases of prematurely born babies, neonatals, that require the use of Extracorporeal Membrane Oxygenators (ECMO) wherein a blood loop is formed with the ECMO to oxygenate the blood for days, if needed, until the proper maturation of lung functions is attained. It is a critical setting, and continuous monitoring of the blood components such as hemoglobin concentration and hematocrit among other properties, can be vital. Further, the use of loop 500 in the ECMO eliminates the undesirable need to withdraw blood samples for these analyses from the neonatal infant already in critical condition.

During the experiments recited in the examples below, it was found that approximately a 15 minute time difference exists in a mammal before any change in the concentration of oxyhemoglobin was observed after the oxygenation has been changed during the operative period. It was also noted in those experiments that approximately 3 to 4 minutes thereafter were required to complete the change of oxygenation level. Thus, nearly 20 minutes exists between the time the change in oxygenation is commenced and the oxygenation has stabilized. Current operative therapeutic monitoring involves the withdrawal of blood samples from the patient and the delivery of those samples to a remote location for static condition analysis. By the time the sample is analyzed the next stage of oxygen change may commence, thereby requiring constant withdrawal of blood samples and repeated analyses in the static condition, which delays the efforts to monitor the true hemoglobin concentration and the state of its oxygenation.

Use of a flow through cell 510 or an extracorporeal blood gas sensor with a cell 510 permits real time monitoring of the time taken to commence and complete the oxygenation change as well as maintaining in real time a monitor of the patient's condition for properties of interest such as hematocrit, hemoglobin concentration, and percent oxygen saturation.

Without being limited thereto or thereby, the following examples illustrate the methods of the present invention used to predict hematocrit and hemoglobin in whole blood in a dynamic condition using an extracorporeal blood loop.

## EXPERIMENTAL PROCEDURE FOR EXAMPLES

30

On two separate occasions, a number of whole blood spectra of canines were observed in an extracorporeal blood loop having the assembly of components depicted in FIG. 14 and described immediately above. During the course of the gathering of such spectra a number of whole blood samples were withdrawn from such canines for independent quantification of the hemoglobin concentration through the use of an "IL482" co-oximeter available from Instrumentation Laboratories or an "ABL2" blood gas analyzer available from Radiometer of Copenhagen, Denmark and independent quantification of the hematocrit by centrifuging. Also, a blank reference spectrum was obtained using an air filled cell. The diffusely transmitted light was gathered after traveling through each sample in the flow through cell 510 described above and also depicted in FIG. 1 as item 113.

All of the measurements were taken at canine body temperature, which fluctuated randomly during the spectra gathering over a range of about  $\pm$  three degrees C. or less.

Specifically, an extracorporeal blood loop was established for both of the individual sessions: the spectra set A was gathered using a 11 Kg female Beagle dog approximately two years old; and the spectra set B was gathered using a 11 Kg. female Beagle dog approximately four and one half years old. While there were some minor variations during the experimentation, the experiments used the following protocol with the following materials, instruments, and supplies.

The materials and instrumentation used for the experiment are identified by reference letters schematically in FIG. 14 and were the following:

A respirator, R, made by Bird Corporation of Palm Springs, California coupled to a semi-open anaesthesia system made by Fortec/Cyprane of Keighley, Yorkshire England connected to various pure gases such as oxygen and a mixture of 5 percent oxygen in nitrogen made by Union Carbide, Linde Division of Danbury, Connecticut sold under the trademark "MEDIBLENDTM" gases;

Heated water blankets, B, "Model K20" sold by American Pharmaseal Company, American Hospital Supply Corporation, Valencia, California; "THINSULATE<sup>®</sup>" brand thermal blankets, B, made by Minnesota Mining and Manufacturing Company;

A "BURDICK" CS525 EKG-Blood Pressure Monitor, M, with a blood pressure transducer connected thereto, made by Burdick Corporation of Milton, Wisconsin;

## EP 0 419 223 A2

EKG Pregelled Electrodes #2256 made by Minnesota Mining and Manufacturing Company; cannulae, 2-1/4" long, 14 gauge made of polytetrafluoroethylene and sold under the trademark "JELCOTM" made by Jelco Labs, Rariton, New Jersey;

- Needle thermometers connected to a LED readout temperature monitor, T, available as "YSI-400" brand monitor made by Yellow Springs Instruments Company, Inc. of Yellow Springs, Ohio;
- 5 The blood loop 500 comprising "TYGON<sup>®</sup>" tubing, generally 520, having a 1.587 mm wall and a 3.175 mm internal diameter made by Norton Performance Plastics of Akron, Ohio; three-way stopcock valves, generally 530, sold under the trademark "INTRALOK<sup>®</sup>" made by Abbott Sorenson Research of Salt Lake City, Utah, a flow through cell 510 of approximately 1.6 mm path length made of quartz-plate glass made at
- 10 Minnesota Mining and Manufacturing Company for this experiment;
- A Model 6250 Pacific Scientific Infrared Spectrometer, S, having the structure described with reference to FIG. 1 and operating in wavelength ranges from 680 nm to 1235 nm;
- An IBM PS/2 Personal Computer, C, available from IBM Corporation of Boca Raton, Florida;
- A micropipette centrifuge, MC, made by Heraeus Sepatech GmbH of West Germany and distributed in the
- 15 United States by American Scientific Products of Minneapolis, Minnesota;
- An Instrumentation Laboratories "IL-482" co-oximeter, O, made by Instrumentation Laboratories of Lexington, Massachusetts;
- A "BECKMAN GPR" refrigerated centrifuge, RC, made by Beckman Instruments;
- An electro-surgical generator, ES, "Model 600" electrosurgical unit made by Minnesota Mining and
- 20 Manufacturing Company or "MODEL 9900" electrosurgical unit available from Concept Incorporated of Clearwater, Florida with a scalpel and dispersive plate system using "SCOTCHPLATE" 1145 dispersive plate and electrically conductive gel "#1103", both available from Minnesota Mining and Manufacturing Company;
- A "ABL-2" Blood Gas Analyzer, BG, made by Radiometer of Copenhagen, Denmark, represented in the
- 25 United States by Radiometer America Inc. of West Lake, Ohio; and
- A number of hand-held, test strip blood drop glucose testers commercially available under the name "GLUCOSTIX<sup>®</sup>" made by Miles Laboratories of Elkhart, Indiana.

Medical and surgical supplies used for the experiment are as follows:

- Lactated Ringers Solution, L, for injection, USP, 1,000 ml made by Abbott Laboratories, North Chicago,
- 30 Illinois;
- 0.9 percent NaCl injection, USP 1,000 ml bag, N, made by Abbott Laboratories, North Chicago, Illinois;
- "ISOFLURANE-AERRANE<sup>®</sup>" anaesthesia agent made by Anaquest of Madison, Wisconsin;
- "LYPHOMED" heparin sodium 1000 units per ml anticoagulant commercially available from Lyphomed Inc. of Rosemount, Illinois;
- 35 Acepromazine maleate commercially available under the name "ACE<sup>®</sup>, AVECOTM" from Ayerst Laboratory Inc of New York, New York in 10 mg per ml dosages;
- Atropine Sulfate Injection, 1/120 grain commercially available from Anpro Corp of Arcadia, California;
- "BIO-TAL" thiamylal sodium, USP injection available from Bioceutric Division, Boehringer Ingelheim Animal Care Inc. of St. Joseph, Missouri;
- 40 and various commonly available and used supplies such as sutures and the like.

- The method of the experiment was as follows: the Beagle dog was first administered by subcutaneous injection 0.05 mg/Kg of the sedative Acepromazine and then 0.025 mg/Kg of Atropine. Anaesthesia was induced by the administration of the barbituate Bio-tal (4%) to obtain the desired level of anaesthesia which was then sustained by the intubation of the trachea and maintained with a mixture of isoflurane in pure
- 45 oxygen from the respirator, R.

The skin was shaved on the medial aspects of the hind legs and the neck for placement of the cannulae and the animal was transferred from initial preparation areas to the operating room.

- A jugular vein cut-down at the shaved neck area was performed and the teflon cannula was inserted and connected to a drip bag containing the lactated Ringers Solution, L, dripping at the rate of 2 to 5 ml per
- 50 pound per hour. The anaesthesia was maintained by continued delivery of isoflurane at 1-2 percent delivered in pure oxygen via the semi-open anaesthesia system. Three EKG electrodes were attached on the thorax of the animal at appropriate diagnostic locations and connected via cables to the Burdick CS525 EKG-Blood Pressure Monitor, M.

- A "SCOTCHPLATE<sup>®</sup>" 1145 Electro-surgical plate (not shown in FIG. 12) was placed under the animal
- 55 on the back with an electrically conductive paste (Gel #1103 available from Minnesota Mining and Manufacturing Company) between the plate and the skin. An electro-surgical scalpel, (not shown in FIG. 12) was attached to an electro-surgical unit (ESU) generator, ES, and used to make a skin incision over the proximal medial femur with dissection carried down to expose the femoral artery and vein. Fourteen gauge

## EP 0 419 223 A2

"TEFLONTM" cannulae were inserted into the femoral artery and vein, respectively, and tied in place with a 2-0 vinyl suture. Next, the contra-lateral femoral artery similarly exposed and a 14 gauge cannulae was inserted and similarly secured with suture. This latter cannulae was connected to the Burdick Corporation blood pressure transducer, M, and connected via hydraulic lines to a pressurized bag containing 0.9 percent sodium chloride solution dripping at approximately 3 ml per hour to prevent any clogging of the cannula.

Heated water blankets, HB, with "THINSULATE<sup>R</sup>" blankets, B, were placed under and over the animal to help maintain body temperature at the initial temperature of 34.8 °C as measured by inserting the needle thermometer near the site of the contra-lateral femoral artery to indicate the core body temperature in the intestinal area. The thermometer readings were displayed on the "YSI-400" Readout Temperature Monitor, T. A second channel of that monitor was connected to a thermometer needle inserted into the tubing section 523 at the outlet port of the blood flow through cell 510 to monitor the temperature of the blood in the extracorporeal loop 500. The "TYGON<sup>R</sup>" tubing was assembled in lengths from about 30 cm to 50 cm. One stop cock valve, 532, was placed in the diversion section of the loop between tubing 521 and 522. A second stop cock valve, 536, was placed in the return section of the loop between tubing 524 and 525. Between the two valves, 532 and 536, a piece of tubing 526 was connected to provide a bypass, which by manipulation of the two valves, 532 and 536, could eliminate flow of the blood through the flow through cell 510 entirely, or to control the rate of flow therethrough.

A third stopcock valve, 534, was placed in the return section of the extracorporeal blood loop 500 between tubing 523 and 524 to permit withdrawal of samples periodically for testing of various blood related parameters using the centrifuge, MC, the co-oximeter, O, the blood gas analyzer, BG, and the glucose test strips. The flow through cell 510 was connected to the opposing ends of the diversion section at tubing 522 and the return section at tubing 523 and placed within the Model 6250 Spectrometer.

Initially the cell 510 and associated tubing 520 was filled with a 0.9% NaCl solution made by Abbott Laboratories of North Chicago, Illinois in order to remove air from the cell 510 and tubing 520 to avoid injection of air emboli upon connection of the extracorporeal loop 500 to the animal and to allow recording of a spectra of water so that known features of the water may serve as a reference of the proper functioning of the loop 500 and spectrophotometric system depicted in FIG. 1. The flow through cell 510 was approximately 6 cm long and 3.5 cm wide at the middle of the cell and mounted onto a transport metal plate of the dimensions of 11 cm by 6 cm with a circular aperture of approximately 1.5 cm. The plate was inserted into the positioning tracks of the chamber and the Model 6250 Spectrometer, S. The chamber cover was shut and taped to prevent accidental opening during the experiment.

The computer control of the cell transport mechanism was disabled by disconnecting the transport board cable between the PS/2 Personal Computer, C and the Model 6250 Spectrometer, S. This was done to prevent movement of the cell 510.

To further prevent any aberrations of the spectrometer, S, receiving incident light, the tubing 522 of the loop 500 leading to and the tubing 523 coming from the Model 6250 Spectrometer, S, was wrapped with black vinyl electrical tape available from Minnesota Mining and Manufacturing Company. Thus, the tubing itself was prevented from acting as a light guide which upon entering the cell would serve as a noise source of light.

Next, the animal was injected with 3800 units of sodium heparin from a 1,000 unit/ml solution available under the brand name "LYPHOMED". The heparin served as a blood anticoagulant because the blood in the extracorporeal loop would be in contact with various materials such as the "TEFLONTM" cannulae, valves 530, tubing 520, and the flow through cell 510.

Next the reference spectrum with air in the cell was taken and stored. Then, the loop 500 was filled with saline, making sure all trapped air bubbles were removed and then connected to patient, P.

The diversion section tubing 522 was connected to the inlet port of the cell 510 so that any spurious air bubbles would be flushed from the cell 510. Next, the extracorporeal loop 500 was adjusted at valves 532 and 536 to permit the animal's blood to flow from the animal through the flow through cell 510 and back to the animal, avoiding the bypass tubing 526 between the diversion section valve 532 and the return section 536 which would eliminate blood flow through the flow through cell 510.

After allowing the blood to flow through the cell 510 for approximately 10 minutes, a 1 ml sample of blood in a 1 ml syringe was withdrawn through valve 534 and subjected to blood gas analysis and co-oximetry and centrifuging. Less than 10 seconds after the withdrawal of the blood sample, 64 scans of spectra were acquired by the spectrometer upon initiation from the personal computer. Approximately 24 seconds were required to obtain these spectra.

Strict adherence to the protocol of blood sample handling is required to minimize aberrations. For example, blood is withdrawn into new syringes for every sample. The operation of the valve 534 where the

## EP 0 419 223 A2

blood is withdrawn must be such that only blood exiting the flow through cell 510 fills the syringe in order to avoid any blood which has proceeded further in the direction of the return to the animal has not been also withdrawn. A first one-third to one-half ml of withdrawn blood is reinjected into valve 534 positioned to direct such reinjected blood into section 524 and towards the animal. This procedure helps to force any old blood  
 5 and/or air in the valve from being also withdrawn. The next one ml of blood withdrawn in the syringe is removed for analysis by instruments, O, MC, and BG. Further, the blood from the syringe is injected into all three of the diagnostic analyzers, O, BG, and MC as soon as possible, within less than a minute, in order to obtain accurate readings not affected by atmospheric changes to the samples.

While the animal was on 100 percent inspired oxygen and confirmed by the samples analysis, the gas  
 10 was changed to a mixture of 5 percent oxygen in nitrogen. After approximately 9 minutes, another blood gas analysis was performed by withdrawal of a blood sample through valve 534 and placement in the diagnostic analytical equipment described above.

Although the percentage oxygen fell from 642 to 507 mm of Hg, the oxygen saturation of the hemoglobin was unchanged at 99.5 percent. It has been found that oxygen saturation decreases signifi-  
 15 cantly only when the percentage oxygen falls below approximately 100 mm of Hg. Because of the time delay from the change in oxygen inspiration until the oxygen saturation had stabilized, the next blood gas analysis was not taken until approximately 22 minutes. That analysis showed  $PO_2$  of 53.3 mm of Hg and  $O_2$  saturation of 93.8 percent.

Twenty-six minutes after changing the gas to 5 percent oxygen, the blood gas analysis showed an  
 20 oxygen saturation of 68.6 percent with a corresponding  $PO_2$  of 27.8 mm of Hg. Immediately after each blood gas analysis, the 64 spectra were recorded by the spectrometer, S, by initiation from the personal computer keyboard, C.

Next, using two 60 ml syringes, 100 ml of blood were withdrawn slowly from the valve 534 on the return section of the blood loop. To assure life sustaining blood pressure, the blood pressure EKG monitor, M, was  
 25 closely watched and the drip flow rate of the lactated Ringer solution, L, was increased for a few minutes to at least one drop a second to bring back or otherwise sustain blood pressure if it drops significantly from the original values recorded, 102/58 mm of Hg.

The 100 ml of blood withdrawn was centrifuged at 3000 RPM for 10 minutes in 2 centrifuge tubes of equal volumes and weights in a "BECKMAN GPR" refrigerated centrifuge, RC, utilizing a "GH-3.7" rotor  
 30 available as catalog #349702 from Beckman Instrument, Inc. of Palo Alto, California. The plasma supernatant fraction was removed with a pipette from each tube and the densely packed red blood cells in the lower portion of the centrifuge tubes were stored in the refrigerator at approximately 4° C.

The plasma was returned to the animal through the same valve 534 to maintain plasma volume but with a reduced hematocrit and hemoglobin concentration.

35 The procedure of withdrawing 100 ml of blood, centrifuging it, re-injecting the plasma and storing the red blood cells in the refrigerator was repeated several times. Each time, the blood gas analysis was performed and the spectra taken both before and after each such procedure. The hematocrit varied for each animal, e.g. for one animal from an initial percent of about 47 percent to a low of about 22 percent, at which point the refrigerated red blood cells were re-injected into the animal through the valve in the return section  
 40 of the loop to increase the hematocrit to its original level and to restore the hemoglobin concentration. Spectra were taken before and after the red blood cell re-injection into the loop and contributed to the spectra used for the training set spectra from which the mathematical regression techniques after pre-processing established the mathematical correlation between the hemoglobin concentration or hematocrit and the water content of the blood.

45

## EXAMPLES 1-6

50

## SECOND DERIVATIVE PRE-PROCESSING TECHNIQUE

55

## EXAMPLE 1

The two experimental sessions were conducted according to the experimental procedure described



## EP 0 419 223 A2

above. Table I below identifies the sessions as sets A and B, and the number of samples analyzed are identified as the number of spectra obtained, which varied as shown. A representative group of samples from set A are graphed in FIG. 4. The sample spectra indicated the ranges of variability of the spectral data found, against which mathematical correlations would have been otherwise attempted to be calculated.

5 Through the use of centrifuging with centrifuge, MC, the hematocrit (Hct) found for both sets is expressed in Table I below as a range which varied from as low as 22 percent to as high as 47 percent. Similarly, the hemoglobin concentration (Hb) range in both sets was determined by cell lysing in the IL482 co-oximeter, O. The range for the sets was from about 8.0 to about 16.6 grams per deciliter (g/dL). Finally the percent oxygen saturation range (O<sub>2</sub> Sat.) in both sets was determined using the co-oximeter, O. The  
10 range for the sets was from 61 percent to 100 percent. Within each set, individual samples having oxygen saturation greater than 95 percent were segregated and assigned to a subset, A1 and B1, respectively, to distinguish the methods of the present invention between samples of nearly fully oxygenated conditions and conditions where oxygen saturation varied considerably.

15 Table I below further identifies the correlation of hematocrit to hemoglobin which demonstrated correlation for the spectra observed greater than 0.99 for both sets.

TABLE I

Sets of Samples Spectrally Analyzed and Independent Quantification Ranges of Hematocrit, Hemoglobin and Oxygen Saturation					
Set	No. of Spectra	Hct Range (%)	Hb Range (g/dL)	Hct/Hb Corr.	O <sub>2</sub> Sat. Range (%)
A	19	22-47	8.0-16.6	0.999	67.0-100.3
A1	14	22-47	8.2-10.7		99.2-100.3
B	8	24-32	8.2-10.8	0.995	61.2- 99.8
B1	6	24-31	8.0-10.7		98.5- 99.8

20 With the spectra detected, involving both the measurement of the diffuse transmission spectra and the transformation of that spectra to absorbance spectra, the analysis described in FIG. 2 and FIG. 3 was performed, using the second derivative transformation pre-processing technique and the ratio pre-processing technique, respectively, for the analysis of both hematocrit and hemoglobin.

25 While a total of 27 individual spectral detections were obtained in two sets for this example, from two individual canines, generally, it is possible to develop a training set and independent quantification training set spectral data from as few as 25 samples to as many as an infinite number of samples. When spectra in  
30 Sets A and B having greater than 95 percent oxygen saturation were segregated into Sets A1 and B1, respectively, 20 spectra were used in some of the following examples together or separately to form the training set or to validate the method. However, based on other work of some of the applicants, such as that disclosed in the European Patent Publications identified above, of the suitability of the techniques in other applications, for these purposes, the use of 20 spectra was deemed sufficient as proof of the propriety of  
35 the method of the present invention even though a more robust sampling is preferred.

40 The purpose of establishing a training set for comparisons and prediction purposes is to attempt to anticipate sampling differences which may exist in various individuals at various times. In other words, the training set should be as broad as possible to include as many variances within each of the factors affecting the measurement of the property of interest.

45 Ideally, the training set includes samples that represent all of the different kinds of changes in the hematocrit and hemoglobin concentration over a full range of values likely to be encountered in an unknown sample as well as all of the other kinds of changes within each factor likely to affect blood sampling, e.g., temperature, amount of liquids, details of light scattering, presence of other components, and physiological condition of the patient.

50 Notwithstanding such ranges of hematocrit and hemoglobin in these sets, it is seen that the correlation between hematocrit and hemoglobin is quite precise, greater over 0.99 in both sets.

55 Having established both training sets A and B and independently quantifying the hematocrit and hemoglobin ranges within each of those sets, the mathematical analysis depicted in FIG. 2 was performed.

## EP 0 419 223 A2

First, the second derivative pre-processing technique was performed against the combination of the sets using the Near Infrared Spectral Analysis software program described above, with a personal computer described above, and available with the Model 6250 spectrometer from Near Infrared Systems to compute the second derivatives, to perform the linear regression, to select the best wavelength, and to save the regression coefficients (steps 124, 125, 127, 128, and 131 of FIG. 2). Other software, "VAX IDL Interactive Data Language" available from Research Systems, Inc. (copyright 1982-1988) was used to apply the regression model, predict the property, (steps 132 and 133 of FIG. 2) and to compute the SEC, SEP, and the bias for validation purposes. In these Examples the approximated second derivative spectra obtained was based on the use of segment of 20 datapoints or 15.8 nm and a gap of 0 datapoints. Thus, each point for purposes of calculating the second derivative was a band 15.8 nm wide without any gap between the bands.

The group of spectra for Set A are shown in FIG. 4 are re-depicted in FIG. 5 after the second derivative pre-processing has been performed. As may be readily seen, the variations in absorbances as caused by baseline offsets and other variances from spectrum to spectrum are minimized, permitting better attempted mathematical correlation.

The second derivative pre-processing technique computes a transformed absorbance value for all of the wavelengths in order to find the best correlation in the area of the water absorbance peak.

For the analysis of hemoglobin, Sets A and B were combined, comprising 27 spectra. Using second derivative transformation as the pre-processing technique, the mathematical analysis depicted in FIG. 2 was performed and yielded a wavelength of 892 nm with a multiple correlation coefficient (R) of 0.991 and a standard error of calibration (SEC) of 0.39 g/dL. However, this wavelength is within a region of the spectrum where a broad absorbance peak of hemoglobin exists and which peak is dependent upon on the percent oxygen saturation. Further use of a wavelength chosen from a set of spectra which is near the minimum number of spectra desired for a versatile training set can be rejected because the smaller training set can invert the priority of correlation of the various wavelengths to the actual value determined by independent quantification.

Another reason for rejection of a wavelength in the 900 nm region of broad hemoglobin absorbance is the possible interference by other forms of hemoglobin absorbing in this region, such as methemoglobin.

Therefore, to find a wavelength which did not exist in a region substantially affected by the spectra of the various forms of hemoglobin, a correlation plot was generated, using the Near Infrared Spectral Analysis software described above or the "VAX IDL, Interactive Data Language" described above. FIG. 6 depicts that correlation plot. As seen in FIG. 6, the correlation in the region of 890 nm is an anomalously sharp band where variations in the wavelength selected can significantly reduce the extent of correlation. Conversely, the correlation in the region of 1150 to 1190 nm is a broader band where variations in the wavelength selected do no significantly reduce the extent of correlation. As discussed below, predictions using a wavelength within this range are acceptable.

From that plot, it was found that in the range of 1150 to 1190 nm corresponding to the broad absorbance peak of the water content, use of a wavelength within the range of 1160-1175 nm, specifically, 1170 nm, had acceptable correlation for generating a calibration equation. The results of the mathematical analysis computed from using the Near Infrared Spectral Analysis software described above and the VAX IDL software described above in the same manner as described earlier in this Example using 1170 nm yielded a R = 0.9064, and SEC = 1.20 g/dL. The slope was 126.3, and the intercept was 3.132. Thus, in this instance, the linear functional equation using a single independent variable was:  
Concentration of Hemoglobin =  $3.13 + 126.32 * (\text{Second Derivative of Spectral Intensity at Wavelength } 1170 \text{ nm})$

By choosing to concentrate on the water absorbance peak around 1150 to 1190 nm, and particularly around 1160 to 1175 nm where there is far less absorbance of either form of hemoglobin than in the region of 925 nm, the mathematical correlations achieved were deemed more acceptable because the correlation was more resistant to errors caused by variations in percent oxygen saturation, and as seen below, SEP and bias were acceptable. Thus, applying the multiple derivative transformation pre-processing technique, variability is minimized when using a wavelength corresponding to the absorbance of the water content in whole blood.

## EXAMPLE 2

To validate the performance of the correlation model at about 1170 nm, the combined sets A + B were

## EP 0 419 223 A2

then used as a known set to predict sets A, A1, B and B1, as if such were unknown. The Near Infrared Spectral Analysis software was used to generate the model combining Sets A and B, and the VAX IDL software was used to compute the results. Table II shows the results found.

TABLE II

Prediction of Individual Sets Against Combined Set A + B For Hemoglobin at 1170 nm After Second Derivative Pre-Processing			
Set	R	SEC g/dL	Bias g/dL
A1	0.995	0.84	0.56
A	0.930	1.13	0.03
B1	0.993	0.72	0.57
B	0.456	1.31	-0.07

The distinctions between the prediction of sets A and B compared with sets A1 and B1 were multiple. The prediction performed well using sets A1 and B1 when the percent oxygen saturation was measured as greater than 95 percent. Correlation R was more precise with the segregated sets A1 and B1, and SEC's were less than 1.0 g/dL. However, the five spectra of set A not found in set A1 and the two spectra of set B not found in set B1 lowered the R and raised the SEC, indicating a less precise prediction achieved. Further, the bias trended more negatively as the lower percent oxygen saturation spectra were included in the set predicted, indicating the lower percent oxygen saturation spectra individually were predicted consistently lower than the higher percent oxygen saturation spectra.

While the use of the second derivative pre-processing technique at the spectral intensity of around 1170 nm wavelength is acceptable for certain instances in a dynamic condition, the acceptability is more apparent under conditions where the percent oxygen saturation is greater than 95 percent.

## EXAMPLE 3

The validation of the performance of the selected linear functional equation described in Example 1 was performed to assess standard error of prediction (SEP) and bias. Each set was used as a known and used to predict each other set as if such other set were unknown. The Near Infrared Spectral Analysis software and the VAX IDL software were used in the same manner as described in Example 1 and used in Example 2 to compute the results. Table III shows the results found.

## EP 0 419 223 A2

TABLE III

Prediction of Individual Sets Against Other Individual Sets For Hemoglobin at 1170 nm After Second Derivative Pre-Processing							
Known Set	R	SEC g/dL	Slope	Intercept	Unknown Set	SEP g/dL	Bias g/dL
A1	0.995	0.29	155.7	0.35	B1	0.64	-0.50
A	0.922	1.18	136.2	2.39	B	2.06	-1.24
B1	0.992	0.16	142.5	1.63	B1	0.50	0.39
B	0.406	1.05	43.5	7.48	B	1.40	-0.29
					A1	0.47	0.20
					A	1.18	-0.35
					A1	2.31	-1.13
					A	2.62	-1.49

The same trends found in Table II were more accentuated in the results shown in Table III. The prediction using one segregated set A1 against another, B1, and vice versa demonstrated the precision of the linear functional equation within an acceptable range. The prediction using full set A against full set B, and vice versa, was less acceptable without possible further adjustment using another independent variable such as percent oxygen saturation. The prediction of a segregated set against a full set, e.g., using A1 to predict B, compared with using a full set to predict a segregated set, e.g., using A to predict B1, demonstrated the desirability of having a broadly based known training set. The breadth of the training set must be adequately balanced among spectra of various types. Only two spectra of eight spectra in set A were not present in set B1. Yet those two spectra were so different due to percent oxygen saturation as to effect greatly the R, SEC, SEP, and bias. However, the five of nineteen spectra missing from set A in set A1 did not cause comparable lack of prediction precision. Therefore, planning great variations in the construction of the training set with balance among the variations will provide the better results for precise prediction.

The bias results in Table III demonstrated accuracy of the linear functional equation, when considering known sets A1, B1 and A. Yet the trend in each instance of prediction where the unknown set included spectra having lower percent oxygen saturation was more negative, indicating an under-prediction of the property of interest.

## EXAMPLE 4

The same experiments as those described in Examples 1-3 were conducted for the analysis of hematocrit using the second derivative transformation pre-processing technique computed using the Near Infrared Spectral Analysis software and the VAX IDL software in the same manner as described in Examples 1-3. The combined sets A and B were analyzed for the best wavelength not likely to be rendered inaccurate by changes in concentration of the various forms of hemoglobin, i.e., in the range of 1150-1190 nm. The combined sets having 27 individual spectra, yielded acceptable results.

As in the case of the hemoglobin of Example 1, the wavelength initially selected by the mathematical analysis was around 892 nm, (R = 0.987 and SEC = 1.28%) in the region of a broad hemoglobin absorbance peak. Therefore, using a correlation plot generated in the same manner as that for Example 1, it was determined that use of a wavelength in the region of 1150-1190 would provide acceptable results. The wavelength between 1160 and 1175 nm was chosen, 1169 nm, and provided the following results: R = 0.899 and SEC = 3.47% with a slope of 356.17 and an intercept of 10.19.

The combined set A + B was then used as a known set and the individual sets A1, A, B1, and B were predicted therefrom to assess standard error of calibration. The results are shown in Table IV.

## EP 0 419 223 A2

Table IV

Predict Individual Sets Against the Combined Set For Hematocrit at 1169 nm After Second Derivative Pre-Processing			
Set	R	SEC (%)	Bias (%)
A1	0.996	2.56	1.75
A	0.934	3.21	0.27
B1	0.984	1.77	1.29
B	0.404	3.99	-0.64

As seen in Table IV, sets A1 and B1 were more precise than sets A and B. The change in bias from smaller sets A1 and B1 to sets A and B, respectively, was more negative, again indicating the trend in accuracy of the linear functional equation to under-predict spectra having lower percent oxygen saturation.

The individual sets A1, A, B1, and B were treated as known sets and the other sets were treated as unknown sets to assess standard error of prediction and bias. Table V shows the results obtained.

TABLE V

Predict Individual Sets Against Other Individual Sets For Hematocrit at 1169 nm After Second Derivative Pre-Processing							
Known Set	R	SEC (%)	Slope	Intercept	Unknown Set	SEP (%)	Bias (%)
A1	0.996	0.73	450.0	1.71	B1	2.54	-1.99
A	0.926	3.29	395.3	7.22	B	6.62	-4.21
B1	0.956	0.63	420.1	5.54	B1	0.89	0.47
B	0.362	3.21	117.0	22.43	B	4.52	-1.58
					A1	1.79	1.38
					A	3.14	-0.21
					A1	6.42	-2.54
					A	7.22	-3.52

As seen in comparison with the results shown in Table III, the same or similar trends were found for hematocrit as found for hemoglobin concentration. Segregated sets A1 and B1 provided the more precise predictions, but the larger set A having a better balance of percent oxygen saturation spectra variations predicted set B1 with acceptable precision. The prediction by set B and the prediction of set B showed the effects that two outlier spectra can have on a smaller set having less robustness of spectra.

Bias for the predictions by all of the sets were more positive when predicting the segregated sets A1 or B1 than when predicting the full sets A or B, again indicating an under-prediction is possible when the spectra has a lower percent oxygen saturation.

FIG. 8 is a graph of the comparison of predictions of set A to the actual independently quantified values for hematocrit.

## EXAMPLE 5

55

Thus, it was determined that in the dynamic condition of whole animal blood, better results were obtained consistently when the model was confined to occasions when the samples being analyzed had

## EP 0 419 223 A2

greater than about 95 percent oxygen saturation. While that condition exists in the great majority of patient diagnostic circumstances, there are many occasions when the patient may have less than 95 percent oxygen saturation. For humans, that is known to be in circumstances when the partial pressure of oxygen in the patient is less than about 60 mm of Hg.

Therefore, as an optional methodology, the percent oxygen saturation of the patient was added as an independent variable to the linear functional equation and multiple linear regression analysis or the like was performed as depicted in FIG. 10 in the case of multiple derivative transformation pre-processing. With two animals studied, the percent oxygen saturation was measured for each spectrum using the "IL-482" co-oximeter. That data comprised one column of data used in replacement of one column of spectral data to achieve a multiple variable set of data, which the Near Infrared Spectral Analysis software and the VAX IDL software computed in the manner described in Examples 1-3 to yield the mathematical results.

Table VI shows the results found when individual sets were used to predict other individual sets for hemoglobin where the percent oxygen saturation was added to the mathematical analysis as an independent variable. Table VII shows the analogous results for hematocrit.

TABLE VI

Prediction of Individual Sets Against Other Individual Sets With Adjustment For Percent Oxygen Saturation From A Co-Oximeter For Hemoglobin at 1170 nm After Second Derivative Pre-Processing								
Known Set	R	SEC g/dL	O <sub>2</sub> Slope	Slope	Intercept	Unknown Set	SEP g/dL	Bias g/dL
A	0.996	0.27	-0.109	159.01	11.00	B1	0.76	-0.51
B	0.999	0.16	-0.083	147.63	9.59	B	0.62	-0.32
						A1	0.49	0.28
						A	0.46	0.15

TABLE VII

Prediction of Individual Sets Against Other Individual Sets With Adjustment For Percent Oxygen Saturation From A Co-Oximeter For Hematocrit at 1169 nm After Second Derivative Pre-Processing								
Known Set	R	SEC %	O <sub>2</sub> Slope	Slope	Intercept	Unknown Set	SEP %	Bias %
A	0.997	0.70	-0.305	459.66	31.50	B1	2.97	-2.01
B	0.983	0.69	-0.253	439.55	29.64	B	2.36	-1.62
						A1	2.08	1.68
						A	1.78	1.38

With the use of the complete sets A or B as the known set, a direct comparison was made between the results shown in Tables III and VI and V and VII, respectively. In every instance other than the already acceptable prediction by set A of set B1, use of percent oxygen saturation as a second independent variable provided a higher correlation R, a more precise SEC, a more accurate and precise SEP, and a more accurate bias. Also, the under-prediction reflected in the change in bias between prediction of segregated sets B1 or A1 and full sets B or A was less pronounced.

The greatest adjustment provided by including the percent oxygen saturation as an independent variable occurred with respect to set 9, previously seen as extremely marginal in prediction as either the known set or the unknown set. Thus, the percent oxygen saturation contributes more to the accuracy and precision of the prediction when the percent oxygen saturations for the spectra are more varied.

For a known occasion where percent oxygen saturation is lower than 95 percent or for an unknown occasion, use of a linear functional equation including percent oxygen saturation as a second independent

## EP 0 419 223 A2

variable provided most useful results. FIG. 12 shows the high resolution of accuracy between the method used in this Example 5 and the independent quantification used for the same spectra and how that resolution is more accurate than that shown in FIG. 8.

5

## EXAMPLE 6

The effect of variations in percent oxygen saturation among the spectra was also calculated from the spectra without use of the co-oximeter. The ratio of the wavelengths of 700 and 820 nm, was proportional to the percent oxygen saturation which existed in each sample as it was analyzed. That ratio data from the originally detected spectra replaced one column of transformed spectral data to achieve a multiple variable set of data, which the Near Infrared Spectral Analysis software and the VAX IDL software computed in the manner described in Examples 1-3 to yield the mathematical results. Table VIII shows the results found for hemoglobin when the adjustment for percent oxygen saturation was determined by the ratio described here. Table IX shows the analogous results found for hematocrit.

TABLE VIII

Prediction of Individual Sets Against Other Individual Sets With Adjustment For Percent Oxygen Saturation From A Spectral Ratio For Hemoglobin at 1170 nm After Second Derivative Pre-Processing								
Known Set	R	SEC g/dL	O <sub>2</sub> Slope	Slope	Intercept	Unknown Set	SEP g/dL	Bias g/dL
A	0.997	0.259	13.07	168.9	-11.33	B1	0.94	-0.52
						B	0.73	-0.46
B	0.981	0.242	11.84	166.4	-9.624	A1	0.62	0.48
						A	0.59	0.48

TABLE IX

Prediction of Individual Sets Against Other Individual Sets With Adjustment For Percent Oxygen Saturation From A Spectral Ratio For Hemoglobin at 1170 nm After Second Derivative Pre-Processing								
Known Set	R	SEC %	O <sub>2</sub> Slope	Slope	Intercept	Unknown Set	SEP %	Bias %
A	0.997	0.72	36.46	495.38	-31.18	B1	3.90	-2.19
						B	2.67	-2.18
B	0.970	0.92	36.05	496.69	-28.69	A1	2.72	2.22
						A	2.61	2.22

A comparison of the results shown in Table VIII with Table VI and shown in Table IX with Table VII found that the use of a ratio of wavelengths from the same spectral data as that used in the prediction found the accuracy and precision of the prediction to be comparable.

55

## EXAMPLES 7-10

## RATIO PRE-PROCESSING TECHNIQUE

25

## EP 0 419 223 A2

## EXAMPLE 7

5

The use of a ratio pre-processing technique provided comparable results to the use of the multiple derivative pre-processing technique. Using the same spectra and data as shown in Table I in Example I, the ratio pre-processing method depicted in FIG. 3 was employed using the following Fortran generated software program described herein, with a personal computer, to select the best ratio, to perform the linear regression, and to save the regression coefficients (steps 224, 225, 227, and 228 of FIG. 3). Procedures in the VAX IDL Interactive Data Language software program described in Example 1 were used to perform the ratio pre-processing on the unknown sample, apply the regression model and predict the property, (steps 231, 232, and 233 of FIG. 3) and to compute the SEC, SEP, and bias for validation purposes.

15

Fortran Software Program (Complies with ANSI  
Fortran 77) Copyright, 1989, Minnesota Mining and  
Manufacturing Company

20

```
REAL DATA(200,500),YVAL(200),TEMP(1500)
```

```
REAL DOUT(500,500),NSPEC,NWAVE
```

```
CHARACTER*30 FILEN
```

25

```
WRITE (6, 100)
```

```
100 FORMAT ( ' ENTER THE SPECTRAL DATA FILE NAME: ' )
```

```
READ (5, 101) FILEN
```

```
101 FORMAT (A)
```

30

```
OPEN (20, FILE=FILEN, STATUS='OLD',
```

```
1FORM='UNFORMATTED', ERR=9999)
```

```
READ (20) NSPEC, NWAVE
```

35

40

45

50

55



EP 0 419 223 A2

```

10 WRITE (6,102)
5 102 FORMAT ( ' ENTER SPACING BETWEEN SPECTRAL POINTS: ' )
    READ (5,*) NSKIP
    IF (NWAVE/NSKIP .GT. 500) GOTO 10
    DO 20 I=1,NSPEC
10    READ (20) (TEMP(J), J=1, NWAVE)
    DO 20 J=0,NWAVE/NSKIP-1
20    DATA(I,J+1) = TEMP(NSKIP*J+1)
    CLOSE (20)
15    WRITE (6, 103)
103 FORMAT ( ' ENTER THE PROPERTY DATA FILE NAME: ' )
    READ (5, 101) FILEN
20    OPEN (20, FILE=FILEN, STATUS='OLD',
    1FORM='UNFORMATTED', ERR=9999)
    READ (20) NSPEC
    DO 30 I=1,NSPEC
25    30 READ (20) YVAL(I)
    CLOSE (20)
    AVEY = YVAL(1)
30    DO 40 I=2,NSPEC
40    AVEY = AVEY + YVAL(I)
    AVEY = AVEY / NSPEC
    YFACT = 0.0
35    DO 50 I = 1, NSPEC
50    YFACT = YFACT + (YVAL(I)-AVEY)*(YVAL(I)-AVEY)
    IF (YFACT .LT. 1.0E-06) GO TO 9999
40    ZCORR = 0.0
    DO 80 I=1,NWAVE/NSKIP
    DO 80 J=1,NWAVE/NSKIP
    AVEX=0.0
45    DO 60 K=1,NSPEC
    TEMP(K) = DATA(K,J)/(DATA(K,I)+1.0E-6)
60    AVEX = AVEX + TEMP(K)
    AVEX = AVEX / NSPEC
50    XFACT = 0.0
    XYFACT = 0.0
    DO 70 K=1,NSPEC
55    XFACT = XFACT + (TEMP(K)-AVEX)*(TEMP(K)-AVEX)

```

## EP 0 419 223 A2

```

70 XYFACT = XYFACT + (TEMP(K)-AVEX)*(YVAL(K)-AVEY)
  IF (ABS(XFACT) .LT. 1E-6) DOUT(J,I)=0.0
  IF (ABS(XFACT) .GE. 1E-6)
1DOUT(J,I)=(XYFACT/XFACT)*(XYFACT/YFACT)
  IF (DOUT(J,I) .LE. ZCORR) GO TO 80
10 ZCORR = DOUT(J,I)
  ZXCOL = J
  ZYCOL = I
  ZAVEX = AVEX
15 ZXFACT = XFACT
  ZXY = XYFACT
80 CONTINUE
20 WRITE (6,104) INT(1+(ZXCOL-1)*NSKIP),
  INT(1+(ZYCOL-1)*NSKIP)
104 FORMAT (/, ' NUMERATOR WAVELENGTH: ', I4,
25 1/, ' DENOMINATOR WAVELENGTH: ', I4)
  SLOPE = ZXY/ZXFACT
  WRITE (6,105) ZCORR, SLOPE, AVEY-SLOPE*ZAVEX
105 FORMAT (/, ' CORRELATION COEFF.: ', 1PE11.4,
30 1/, ' SLOPE: ', E10.3,/, ' INTERCEPT: ', E10.3)
  WRITE (6,106)
106 FORMAT ( ' ENTER THE OUTPUT FILE NAME: ' )
  READ (5, 101) FILEN
35 OPEN (20, FILE=FILEN, FORM='UNFORMATTED',
  STATUS='NEW')
  WRITE (20) NWAVE/NSKIP,NWAVE/NSKIP,0.0,0.0
40 DO 90 I=1,NWAVE/NSKIP
  90 WRITE (20) (DOUT(J,I), J=1,NWAVE/NSKIP)
9999 CLOSE (20)
  STOP
45 END

```

The ratio pre-processing technique computed substantially possible wavelength pairs, as described above, in order to find the best correlation in the area of the water absorbance peak and another absorbance measuring point.

For the analysis of hemoglobin, Sets A and 8 were combined, comprising 27 spectra. Using the ratio pre-processing technique, the mathematical analysis depicted in FIG. 3 was performed and yielded a pair of wavelengths of 843 and 1173 nm with a multiple correlation coefficient (R) of 0.996 and a standard error of calibration (SEC) of 0.26 g/dL, with a computed slope of 36.818 and an intercept of -37.807. This pair is in the vicinity of the isosbestic point for oxy and deoxy hemoglobin and the broad absorbance peak of water, respectively. However, for purposes of comparison with the examples of ratio pre-processing technique used in U.S. Patent Application Serial Number 07/408,746, filed by some of the applicants of this application, the pair of wavelengths of 820 and 1161 nm were chosen, which yielded the nearly similar

## EP 0 419 223 A2

results of  $R = 0.983$ ,  $SEC = 0.53$  g/dL, and a slope of 40.347 and intercept of -40.773.

To confirm the selection of the 820/1161 pair of wavelengths, a correlation map was generated, and depicted as FIG. 7 using the VAX IDL, Interactive Data Language software described above.

From that map measuring the lines of equal correlation at 0.875, 0.90, 0.925, 0.95, and 0.975 using the squares of the multiple correlation coefficients, it was found that in the range of 1150 to 1190 nm corresponding to the broad absorbance peak of the water content had a broad plateau. The range of 800 to 850 nm also showed a broad plateau. Pairs of wavelengths within these regions would provide acceptable results.

Thus, in this instance using procedures in the VAX IDL software described above and the ratio of 820 nm to 1161 nm, the linear functional equation using a single independent variable was:  
Hemoglobin  $-40.773 + 40.347 * (\text{Absorbance}_{820} / \text{Absorbance}_{1161})$

Table X shows the results found using this equation as applied to predict each set A1, A, B1, and B against the combined set A + B for hemoglobin concentration.

TABLE X

Prediction of Individual Sets Against Combined Set For Hemoglobin at Ratio of 820/1161 nm			
Set	R	SEC g/dL	Bias g/dL
A1	0.998	0.32	-0.16
A	0.992	0.39	0.00
B1	0.994	0.36	-0.22
B	0.832	0.92	0.14

A comparison of the results found in Table X with the results found in Table II showed the relatively more precise linear functional correlation using the ratio pre-processing technique. However, among the sets studied in Table X, set B showed the effects on precision of lower percent oxygen saturation spectra creating an imbalance within a set of limited numbers for the training set. With adequate balance of variations in the training set spectra, even if the unknown sample's spectrum were quite abnormal, use of ratio pre-processing technique in the formation of the linear functional correlation would have provided acceptable results for calibration.

The validation of the performance of the selected linear functional equation described in this Example 7 was performed to assess standard error of prediction (SEP) and bias. Each set was used as a known and used to predict each other set as if such other set were unknown. Table XI shows the results found.

TABLE XI

Prediction of Individual Sets Against Other Individual Sets For Hemoglobin After Ratio Pre-Processing at 820/1161 nm							
Known Set	R	SEC g/dL	Slope	Intercept	Unknown Set	SEP g/dL	Bias g/dL
A1	0.998	0.20	42.817	-43.793	B1	0.34	-0.21
					B	0.99	0.18
A	0.992	0.39	41.071	-43.683	B1	0.42	-0.27
					B	0.93	0.10
B1	0.995	0.15	43.195	-44.047	A1	0.34	0.24
					A	0.63	0.42
B	0.832	0.70	26.227	-23.170	A1	1.63	-0.99
					A	1.59	-0.98

## EP 0 419 223 A2

The results provide proof of the accuracy and the precision of the linear functional equation for predicting hemoglobin in a dynamic condition of an extracorporeal blood loop of a mammal. Recognizing the effects of outlier spectra in set B as previously described in a smaller set than that to be used in forming the training set, the most precise predictions arise from segregated sets A1 and B1, followed by the predictions of and with set A. The trend in the bias is slightly toward the positive, but all sets were predicting within a range of acceptable bias.

10

## EXAMPLE 8

The same experiments as those described in Example 7 were conducted for the analysis of hematocrit using the ratio pre-processing technique computed using the same software and procedures as described in Example 7. The combined sets A and B were analyzed for the best wavelength pair not likely to be rendered inaccurate by changes in concentration of the various forms of hemoglobin, i.e., in the range of 1150-1190 nm and around the isosbestic point. The combined sets having 27 individual spectra, yielded acceptable results.

As in the case of the hemoglobin of Example 7, the wavelength pair initially selected by the mathematical analysis was around 855 nm and 1161 nm ( $R = 0.993$  and  $SEC = 0.93\%$ ) with the former in the region of a broad hemoglobin absorbance peak. Therefore, using a correlation map generated in the same manner as that for Example 7, it was determined that use of the same wavelength pair of 820/1161 nm would provide acceptable results. That wavelength pair yielded the following results:  $R = 0.982$  and  $SEC = 1.54\%$ , with a slope of 112.74 and an intercept of -113.62.

The combined set A + B was then used as a known set and the individual sets A1, A, B1, and B were predicted therefrom to assess standard error of calibration. The results are shown in Table IV.

TABLE XII

30

35

40

Predict Individual Sets Against The Combined Set For Hematocrit After Ratio Pre-Processing at 820/1161 nm			
Set	R	SEC (%)	Bias (%)
A1	0.998	0.93	-0.29
A	0.991	1.25	0.15
B1	0.987	1.94	-1.25
B	0.835	2.52	-0.35

As seen in Table XII, sets A1 and B1 were more precise than sets A and B. The change in bias from smaller sets A1 and B1 to sets A and B, respectively, was more positive. But all were within acceptable ranges.

The individual sets A1, A, B1, and B were treated as known sets and the other sets were treated as unknown sets to assess standard error of prediction and bias. Table XIII shows the results obtained.

50

55

## EP 0 419 223 A2

TABLE XIII

Predict Individual Sets Against Other Individual Sets For Hematocrit After Ratio Pre-Processing at 820/1161 nm							
Known Set	R	SEC (%)	Slope	Intercept	Unknown Set	SEP (%)	Bias (%)
A1	0.998	0.53	122.53	-126.08	B1	2.32	-1.57
A	0.991	1.18	117.50	-120.02	B	2.80	-0.53
					B1	2.58	-1.75
B1	0.987	0.68	125.02	-127.60	B	2.87	-0.78
					A1	2.03	1.73
B	0.835	2.08	78.72	-70.63	A	2.82	2.29
					A1	3.63	-1.61
					A	3.57	-1.52

As seen in comparison with the results shown in Table XI, the same or similar trends were found for hematocrit as found for hemoglobin concentration. Segregated sets A1 and B1 provided the more precise predictions against each other, but the larger sets A and B have acceptable precision. The prediction by set B and the prediction of set B showed the effects that two outlier spectra can have on a smaller set having less robustness of spectra, although the effect is less pronounced using the ratio pre-processing technique compared with the second derivative transformation pre-processing technique.

Bias for the predictions by all of the sets were more negative when predicting the segregated sets A1 or B1 than when predicting the full sets A or B, indicating a possible over-prediction is possible when the spectra has a lower percent oxygen saturation. But the bias in all sets' predictions is acceptable.

FIG. 9 is a graph of the comparison of predictions of set A to the actual independently quantified values for hematocrit.

## EXAMPLE 9

As counterpoint to the experiments of Example 5, the use of the percent oxygen saturation was employed as a second independent variable while using the ratio pre-processing technique even though consistently acceptable results were obtained with a single independent variable linear functional equation. FIG. 11 depicts the method of the invention altered to adjust for the use of the second independent variable. The 820/1161 nm ratio computed with the VAX IDL software was added with the co-oximeter measurements to produce a linear summation, and then computed with a multiple linear regression analysis procedure of the VAX IDL software to yield the mathematical results. Tables XIV and XV show the results found when including the co-oximeter measurements of percent oxygen saturation into the equation for hemoglobin and hematocrit, respectively.

TABLE XIV

Prediction of Individual Sets Against Other Individual Sets With Adjustment For Percent Oxygen Saturation From A Co-Oximeter For Hemoglobin After Pre-Processing at 820/1161 nm								
Known Set	R	SEC g/dL	O <sub>2</sub> Slope	Slope	Intercept	Unknown Set	SEP g/dL	Bias g/dL
A	0.997	0.23	0.0273	41.506	-44.820	B1	0.33	-0.15
B	0.945	0.46	0.0418	41.935	-46.633	B	0.56	-0.03
						A1	0.30	0.17
						A	0.32	0.11

## EP 0 419 223 A2

TABLE XV

Prediction of Individual Sets Against Other Individual Sets With Adjustment For Percent Oxygen Saturation From A Co-Oximeter For Hematocrit After Ratio Pre-Processing at 820/1161 nm								
Known Set	R	SEC %	O <sub>2</sub> Slope	Slope	Intercept	Unknown Set	SEP %	Bias %
A	0.997	0.67	0.0850	118.86	-129.79	B1	2.55	-1.38
B	0.928	1.58	0.1129	121.17	-134.02	B	2.36	-1.18
						A1	1.91	1.54
						B	1.77	1.42

With the use of the complete sets A and B as the known set, a direct comparison was made between the results shown in Tables XI and XIV and XIII and XV, respectively. In every instance, use of percent oxygen saturation as a second independent variable provided a higher correlation R, a more precise SEC, a more accurate and precise SEP, and a smaller bias, than the already acceptable results using the linear functional equation with the single ratio pair independent variable. While there was less adjustment for set B than found to be necessary in Examples 1-6, there was more adjustment provided by the second independent variable for set 8 than for the other sets. Thus, the percent oxygen saturation contributes more to the accuracy and precision of the prediction when the percent oxygen saturations for the spectra are more varied.

For a known occasion where percent oxygen saturation is lower than 95 percent or for an unknown occasion, use of a linear functional equation including percent oxygen saturation as a second independent variable provided most useful results. FIG. 13 shows the high resolution of accuracy between the method used in this Example 9 and the independent quantification used for the same spectra and how that resolution is more accurate than that shown in FIG. 9.

## EXAMPLE 10

The effect of variations in percent oxygen saturation among the spectra was also calculated from the spectra without use of the co-oximeter. The ratio of the absorbances at the wavelengths of 700 and 820 nm was proportional to the percent oxygen saturation existing in each sample as it was analyzed. The 820/1161 nm ratio computed with the VAX IDL software was added with the 700/820 nm ratio to produce a linear summation, and then computed with a multiple linear regression analysis procedure of the VAX IDL software to yield the mathematical results. Table XVI shows the results found for hemoglobin when the adjustment for percent oxygen saturation was determined by the ratio described here. Table XVII shows the analogous results found for hematocrit.

## EP 0 419 223 A2

TABLE XVI

Prediction of Individual Sets Against Other Individual Sets With Adjustment For Percent Oxygen Saturation From A Spectral Ratio For Hemoglobin After Ratio Pre-Processing at 820/1161 nm								
Known Set	R	SEC %	O <sub>2</sub> Slope	Slope	Intercept	Unknown Set	SEP %	Bias %
A	0.998	0.21	-3.109	40.758	-38.561	B1	0.35	-0.17
B	0.960	0.39	-5.421	40.725	-36.410	B	0.56	-0.02
						A1	0.36	0.24
						A	0.35	0.12

15

TABLE XVII

Prediction of Individual Sets Against Other Individual Sets With Adjustment For Percent Oxygen Saturation From A Spectral Ratio For Hematocrit After Ratio Pre-Processing at 820/1161 nm								
Known Set	R	SEC %	O <sub>2</sub> Slope	Slope	Intercept	Unknown Set	SEP %	Bias %
A	0.998	0.60	-9.647	116.54	-110.40	B1	2.61	-1.43
B	0.943	1.40	-14.858	118.46	-106.91	B	2.30	-1.14
						A1	2.18	1.77
						A	1.88	1.49

30

A comparison of the results shown in Table XVI with Table XIV and shown in Table XVII with Table XV found that the use of a ratio of wavelengths from the same spectral data as that used in the prediction were quite comparable and acceptable.

Embodiments of the invention have been described using examples. However, it will be recognized that the scope of the invention is not to be limited thereto or thereby.

### Claims

40

1. A method for analyzing a property of biological matter having a water content in a dynamic condition, the biological matter comprising a first compartment related to the property to be analyzed and a second compartment having a proportionally larger or smaller amount of water than the first compartment, the method comprising:

- 45 (a) observing multiple samples of biological matter in a dynamic condition;  
 (b) irradiating with near infrared light said multiple samples of the biological matter;  
 (c) detecting the near infrared absorption spectrum of each of said multiple samples;  
 (d) applying a ratio pre-processing technique to the absorption spectrum of each of said multiple samples;  
 (e) independently quantifying the property to be analyzed for each of said multiple samples;  
 50 (f) establishing a training set from said near infrared absorption spectra of said multiple samples; and  
 (g) statistically identifying the nature of a mathematical correlation between the property to be analyzed in the first compartment and the water content in the biological matter;  
 wherein said ratio pre-processing technique comprises applying a ratio of a near-infrared wavelength absorbance peak of the water content in said training set to another near-infrared wavelength absorbance  
 55 measuring point in said training set.

2. A method according to Claim 1, further comprising the steps of:  
 (h) observing an unknown sample of the biological matter in a dynamic conditioning;  
 (i) irradiating said unknown sample of the biological matter with near infrared light;

## EP 0 419 223 A2

- (j) detecting the near infrared spectrum of said unknown sample;  
 (k) applying said ratio pre-processing technique to said spectrum of said unknown sample; and  
 (l) predicting the property to be analyzed in said unknown sample by utilizing said mathematical correlation obtained in said statistically identifying step (g).
- 5 3. A method according to Claim 1, wherein said statistically identifying step (g) uses linear regression analysis, multiple linear regression analysis, stepwise regression analysis, or partial least squares regression analysis.
4. A method according to Claim 1 or Claim 2, wherein said mathematical correlation in said statistically identifying step (g) comprises a linear function related to a near infrared absorbance peak of water in the  
 10 absorbance spectra of said multiple samples subjected to said pre-processing technique.
5. A method according to Claim 1 or Claim 2, wherein the biological matter is whole blood and the property of the first compartment to be analyzed is hematocrit or hemoglobin concentration in the whole blood.
6. A method according to Claim 1 or Claim 2, wherein the biological matter is whole blood and said absorbance peak of water occurs in the near infrared spectra from about 1150 to about 1190 nanometers,  
 15 and said another near infrared wavelength absorbance measuring point is the isosbestic point of oxyhemoglobin and deoxyhemoglobin.
7. A method according to Claim 2, wherein said detecting step (c) and said detecting step (j) use spectral analysis instrumentation which records said absorbance spectra of said multiple samples and said unknown sample in the dynamic condition of the biological matter flowing through the spectral analysis instrumenta-  
 20 tion.
8. A method according to Claim 2, wherein the property to be analyzed is hematocrit and said mathematical correlation solves the equation:  

$$Y = b + m * (\text{Absorbance at an Isosbestic Point of Deoxyhemoglobin and Oxyhemoglobin} / \text{Absorbance at said Absorbance Peak of Water})$$
  
 25 where Y is the value of hematocrit, b ranges from about -70 to about -128, and m ranges from about 78 to about 128.
9. A method according to Claim 2, wherein the property to be analyzed is hemoglobin concentration and said mathematical correlation solves the equation:  

$$Y = b + m * (\text{Absorbance at an Isosbestic Point of Deoxyhemoglobin and Oxyhemoglobin} / \text{Absorbance at said Absorbance Peak of Water})$$
  
 30 where Y is the hemoglobin concentration, b ranges from about -23 to about -45, and m ranges from about 26 to about 44.
10. A method according to Claim 1, further comprising the steps of:  
 (1) observing additional samples of biological matter in a dynamic condition;  
 35 (2) independently quantifying the property to be analyzed for each of said additional samples;  
 (3) performing steps (b), (c), and (d) with respect to said additional samples;  
 (4) predicting the property to be analyzed in said additional samples by utilizing said mathematical correlation obtained in said statistically identifying step (g); and  
 (5) validating said mathematical correlation by comparing the property predicted in step (4) to the  
 40 property independently quantified in step (2).
11. A method for the analysis of a biological fluid having a water content, in a dynamic condition, comprising:  
 observing multiple samples of a moving biological fluid of at least one organism, where the biological fluid may be approximated to comprise two compartments where one compartment has a proportionally different  
 45 amount of water than the other compartment which has a property of interest;  
 determining the two best absorbance detection points of the near infrared spectrum of each of said multiple samples;  
 independently measuring the quantity of the property to be analyzed in each of said multiple samples;  
 applying a ratio of said two best absorbance measuring points;  
 50 identifying a mathematical correlation of the property to be analyzed and the water content in the biological fluid; and  
 analyzing an unknown sample of the biological fluid to determine the property to be analyzed in said unknown sample by applying said mathematical correlation to a near infrared spectrum of said unknown sample.
- 55 12. A method for analyzing a property of whole animal blood having a water content, the whole animal blood comprising a first compartment related to the property to be analyzed and a second compartment having a proportionally larger or smaller amount of water than the first compartment, the method comprising:



## EP 0 419 223 A2

- (a) irradiating with near infrared light multiple samples of the whole animal blood;  
 (b) detecting the near infrared spectrum of each of said multiple samples;  
 (c) applying a pre-processing technique to the spectrum of each of said multiple samples;  
 (d) independently quantifying the property to be analyzed for each of said multiple samples;  
 5 (e) independently quantifying a value proportional to the percentage oxygen saturation in the whole animal blood for each of said multiple samples;  
 (f) establishing a training set from said near infrared spectra of said multiple samples; and  
 (g) statistically identifying the nature of a mathematical correlation between the property to be analyzed in the first compartment and the water content in the whole animal blood.
- 10 13. A method according to Claim 12, further comprising the steps of:  
 (h) irradiating an unknown sample of whole animal blood with near infrared light;  
 (i) detecting the near infrared spectrum of said unknown sample;  
 (j) applying said pre-processing technique to said spectrum of said unknown sample;  
 (k) determining a value proportional to the percent oxygen saturation of the unknown sample; and  
 15 (l) predicting the property to be analyzed in said unknown sample by utilizing said mathematical correlation obtained in said statistically identifying step (g).
14. A method according to Claim 12, wherein said statistically identifying step (g) uses multiple linear regression analysis, multiple stepwise regression analysis, partial least squares regression analysis and wherein said statistically identifying step (g) uses the independently quantified percent oxygen saturation in  
 20 said multiple samples as a regression variable in said analysis to determine said mathematical correlation.
15. A method according to Claim 12 or 13, wherein said mathematical correlation in said statistically identifying step (g) comprises a linear function related to a near infrared absorbance peak of water in the absorbance spectra of said multiple samples subjected to said pre-processing technique and the percent oxygen saturation in said multiple samples.
- 25 16. A method according to Claim 12 or 13, wherein said pre-processing technique comprises transforming said spectra of said multiple samples of said training set by computing a multiple derivative of said multiple samples.
17. A method according to Claim 12 or 13, wherein said pre-processing technique comprises applying a ratio of a near infrared wavelength absorbance peak of the water content in said training set to another near  
 30 infrared wavelength absorbance measuring point in said source spectra set.
18. A method according to Claim 12 or 13, wherein the property of the first compartment to be analyzed is hematocrit or hemoglobin concentration in the whole blood.
19. A method according to Claim 12 or 13, wherein said water content has an absorbance peak in the near  
 35 infrared spectra from about 1150 to about 1190 nanometers and the biological fluid has an isosbestic point of oxyhemoglobin and deoxyhemoglobin and wherein said pre-processing technique comprises applying a ratio of said water content absorbance peak to said isosbestic point.
20. A method according to Claim 13, wherein said detecting step (b) and said detecting step (i) use spectral analysis instrumentation which records said absorbance spectra of said multiple samples and said unknown  
 40 sample in the dynamic condition of the whole animal blood flowing through the spectral analysis instrumentation.
21. A method according to Claim 13, wherein the property to be analyzed is hematocrit and said mathematical correlation solves the equation:  

$$C = B_0 + B_1 (A_1) + B_2 (A_2)$$
 where C is the Hematocrit;  $B_0$  ranges from about -31 to about 32; where  $A_1$  is a value proportional to the  
 45 percent oxygen saturation and  $B_1$  is a regression coefficient for the percent oxygen saturation and ranges from about -0.4 to about 36; where  $A_2$  is a second derivative transformation of an absorbance peak of water and ranges from about 1160 to about 1175 nm and  $B_2$  is a regression coefficient of a second derivative transformation of said absorbance peak of water and ranges from about 439 to about 496.
22. A method according to Claim 13, wherein the property to be analyzed is concentration of hemoglobin  
 50 and said mathematical correlation solves the equation:  

$$C = B_0 + B_1 (A_1) + B_2 (A_2)$$
 where C is the concentration of hemoglobin;  $B_0$  ranges from about -11 to about 11; where  $A_1$  is a value proportional to the percent oxygen saturation and  $B_1$  is the regression coefficient for the percent oxygen saturation and ranges from about -0.08 to about 13; where  $A_2$  is a second derivative transformation of an  
 55 absorbance peak of water and ranges from about 1160 to about 1175 nm and  $B_2$  is a regression coefficient of a second derivative transformation of an absorbance peak of water and ranges from about 147 to about 169.
23. A method according to Claim 13, wherein the property to be analyzed is hematocrit and said

## EP 0 419 223 A2

mathematical correlation solves the equation:

$$C = B_0 + B_1 (A_1) + B_2 (A_2)$$

where C is the Hematocrit;  $B_0$  ranges from about -106 to about -134; where  $A_1$  is a value proportional to the percent oxygen saturation and  $B_1$  is a regression coefficient for the percent oxygen saturation and ranges from about -15 to about 0.1; where  $A_2$  is a ratio of the Absorbance at an Isosbestic Point of Deoxyhemoglobin and Oxyhemoglobin to an Absorbance at an Absorbance Peak of Water and  $B_2$  is a regression coefficient of an absorbance peak of water and ranges from about 116 to about 121.

24. A method according to Claim 13, wherein the property to be analyzed is hemoglobin concentration and said mathematical correlation solves the equation:

$$C = B_0 + B_1 (A_1) + B_2 (A_2)$$

where C is the concentration of hemoglobin;  $B_0$  ranges from about -46 to about -36; where  $A_1$  is a value proportional to the percent oxygen saturation and  $B_1$  is a regression coefficient for the percent oxygen saturation and ranges from about -5 to about 0.02; where  $A_2$  is a ratio of an Absorbance at an Isosbestic Point of Deoxyhemoglobin and Oxyhemoglobin to an Absorbance at an Absorbance Peak of Water and  $B_2$  is a regression coefficient of an absorbance peak of water and ranges from about 40 to about 42.

25. A method according to Claim 12 or 13, wherein said multiple samples are of at least one known organism of a given biological species.

26. A method according to Claim 13, wherein, to measure the percent oxygen saturation of the unknown sample, said determining step (k) comprises using a pulse oximeter, a co-oximeter, or the ratio of absorbances of two wavelengths where the ratio of extinction coefficients for oxyhemoglobin and deoxyhemoglobin at one wavelength is different than that ratio at the second wavelength.

27. A method according to Claim 12, further comprising the steps of:

(1) observing additional samples of biological matter in a dynamic condition;

(2) independently quantifying the property to be analyzed for each of said additional samples;

(3) independently quantifying a value proportional to the percentage oxygen saturation in the whole animal blood for each of said additional samples;

(4) performing steps (a), (b), and (c) with respect to said additional samples;

(5) predicting the property to be analyzed in said additional samples by utilizing said mathematical correlation obtained in said statistically identifying step (g); and

(6) validating by a statistical method said mathematical correlation by comparing the property predicted in step (5) to the property independently quantified in step (2).

28. A method for the analysis of a whole blood having a water content comprising:

observing multiple samples of whole blood of at least one organism, where the whole blood may be approximated to comprise two compartments where one compartment has a proportionally different amount of water than the other compartment which has a property of interest;

determining the best absorbance detection point comprising the absorbance peak of the water content in the near infrared spectrum of each of said multiple samples;

independently measuring the quantity of the property to be analyzed in each of said multiple samples and a value proportional to percent oxygen saturation of each of said multiple samples;

identifying a mathematical correlation of the property to be analyzed and the water content in the whole blood.

29. A method according to Claim 28, further comprising:

analyzing an unknown sample of the whole blood to determine the property to be analyzed in said unknown sample by applying said mathematical correlation to a near infrared spectrum of said unknown sample.

30. A method for monitoring a property of interest in whole blood of a live patient, nearly simultaneously with flow of the whole blood in the patient, comprising:

(a) establishing a blood flow loop having a diversion section departing from the patient terminating at a flow cell, a return section returning to the patient beginning at a flow cell, and a bypass section between the diversion section and the return section;

(b) flowing the whole blood through the blood loop;

(c) using near infrared detecting means to monitor the property of interest in the whole blood flowing through the blood loop; and

(d) identifying the value of the property of interest using a method of correlation of a linear functional relationship;

wherein said linear functional relationship comprises

(1) observing multiple samples of whole blood of at least one organism, where the whole blood may be approximated to comprise two compartments where one compartment has a proportionally different amount of water than the other compartment which has the property of interest;

**EP 0 419 223 A2**

(2) determining the best absorbance detection point comprising the absorbance peak of the water content in the near infrared spectrum of each of said multiple samples;

(3) independently measuring the quantity of the property to be analyzed in each of said multiple samples;

5 (4) identifying a mathematical correlation of the property to be analyzed and the water content in the whole blood.

10

15

20

25

30

35

40

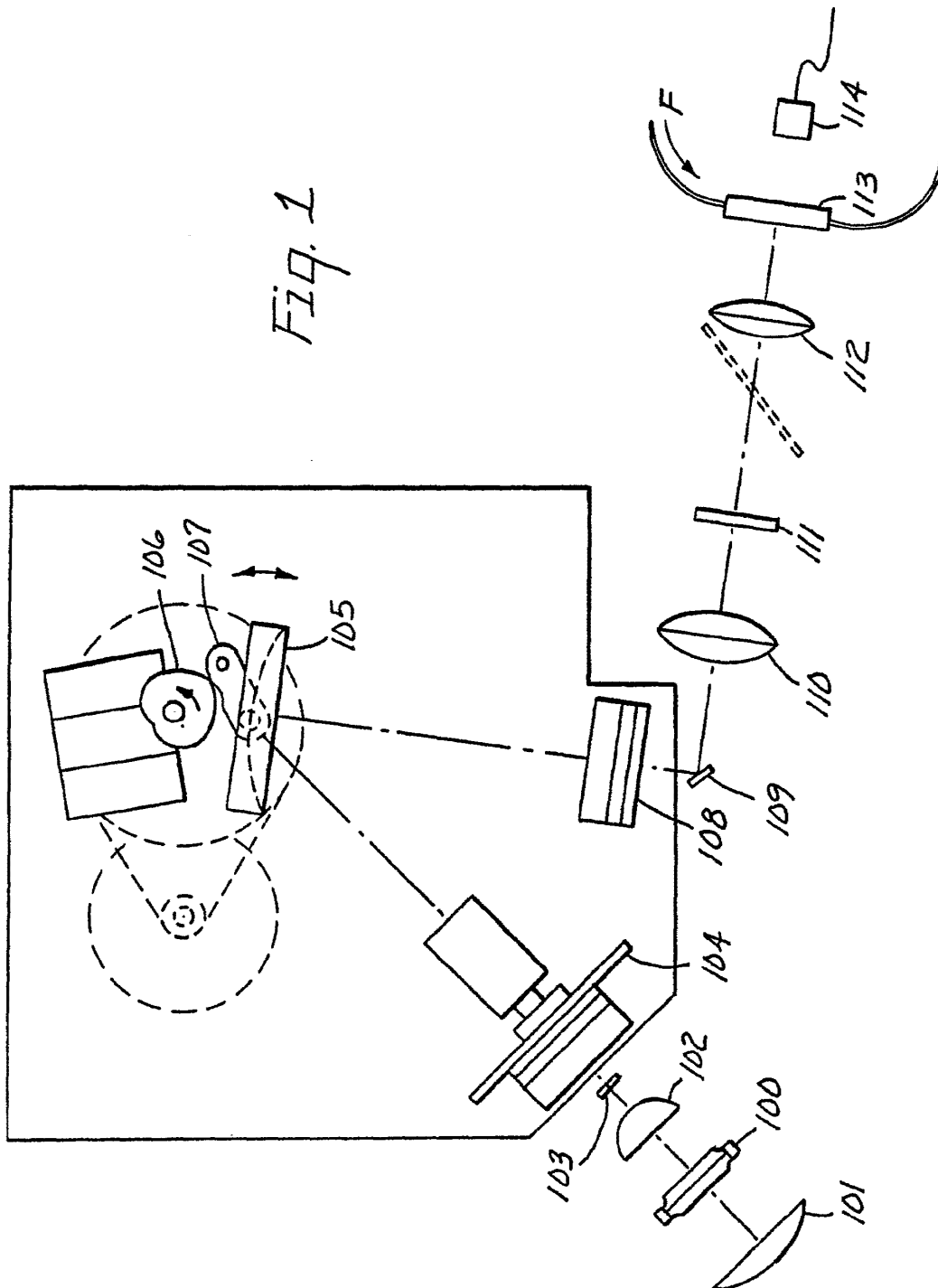
45

50

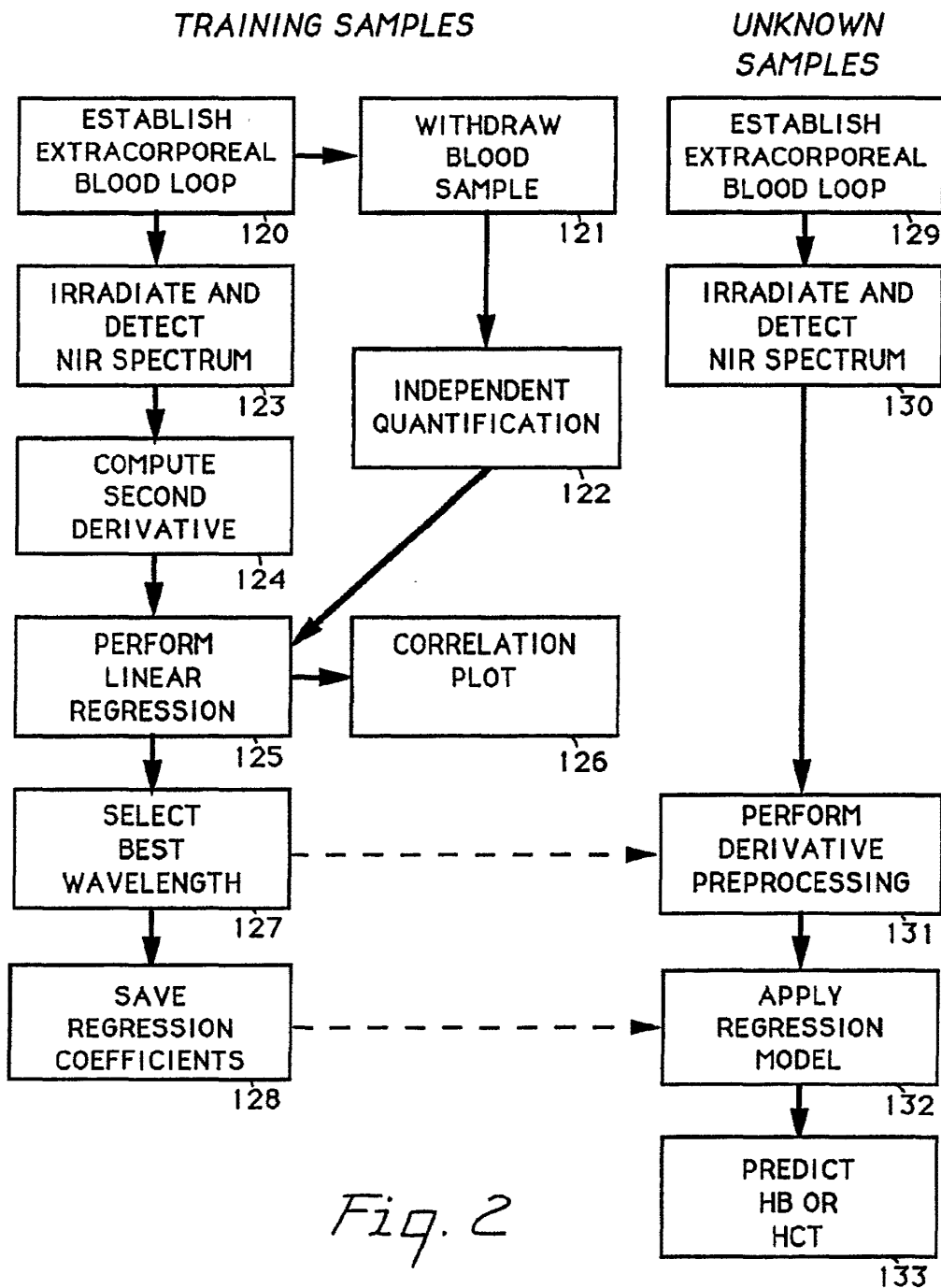
55

EP 0 419 223 A2

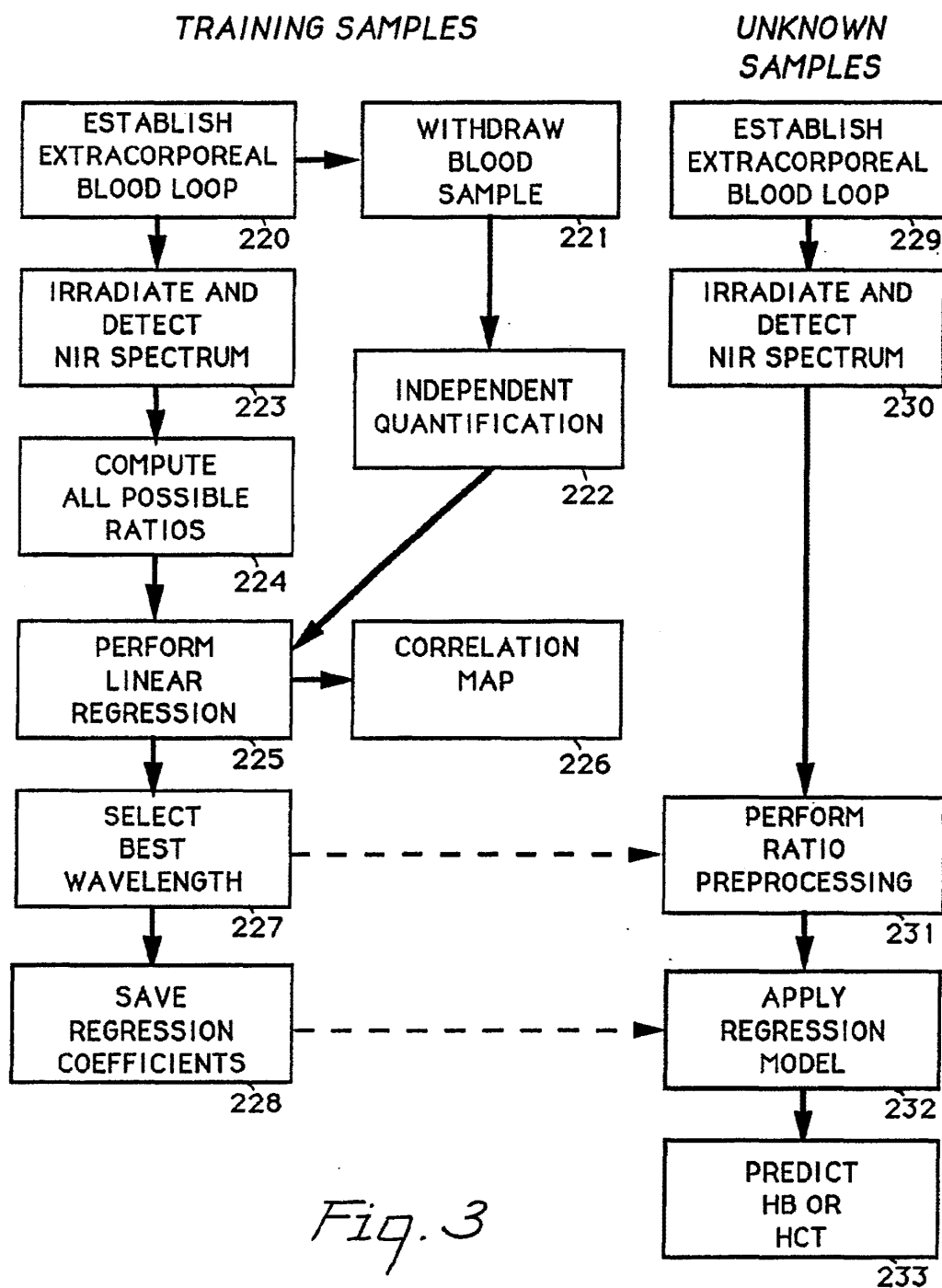
Fig. 1



EP 0 419 223 A2



EP 0 419 223 A2

*Fig. 3*

CX-1622

EP 0 419 223 A2

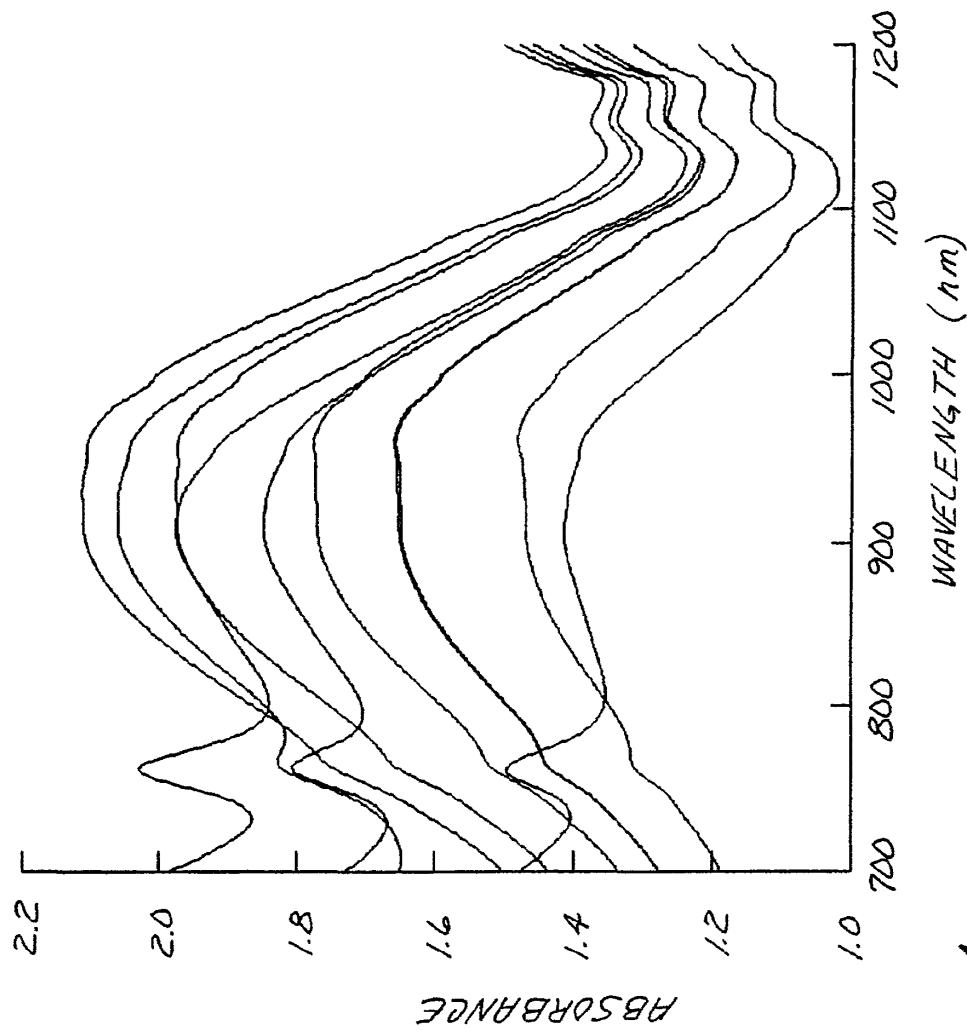


Fig. 4

CX-1622

EP 0 419 223 A2

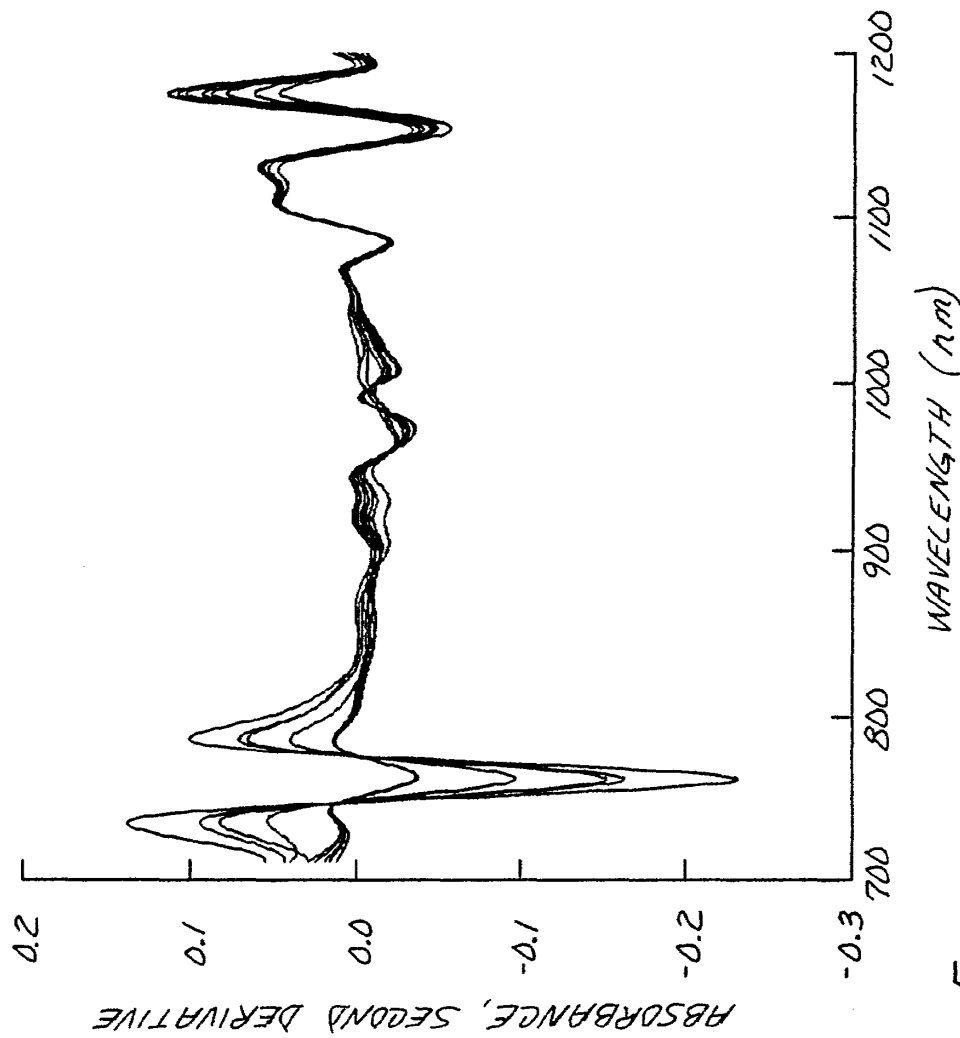


Fig. 5



CX-1622

EP 0 419 223 A2

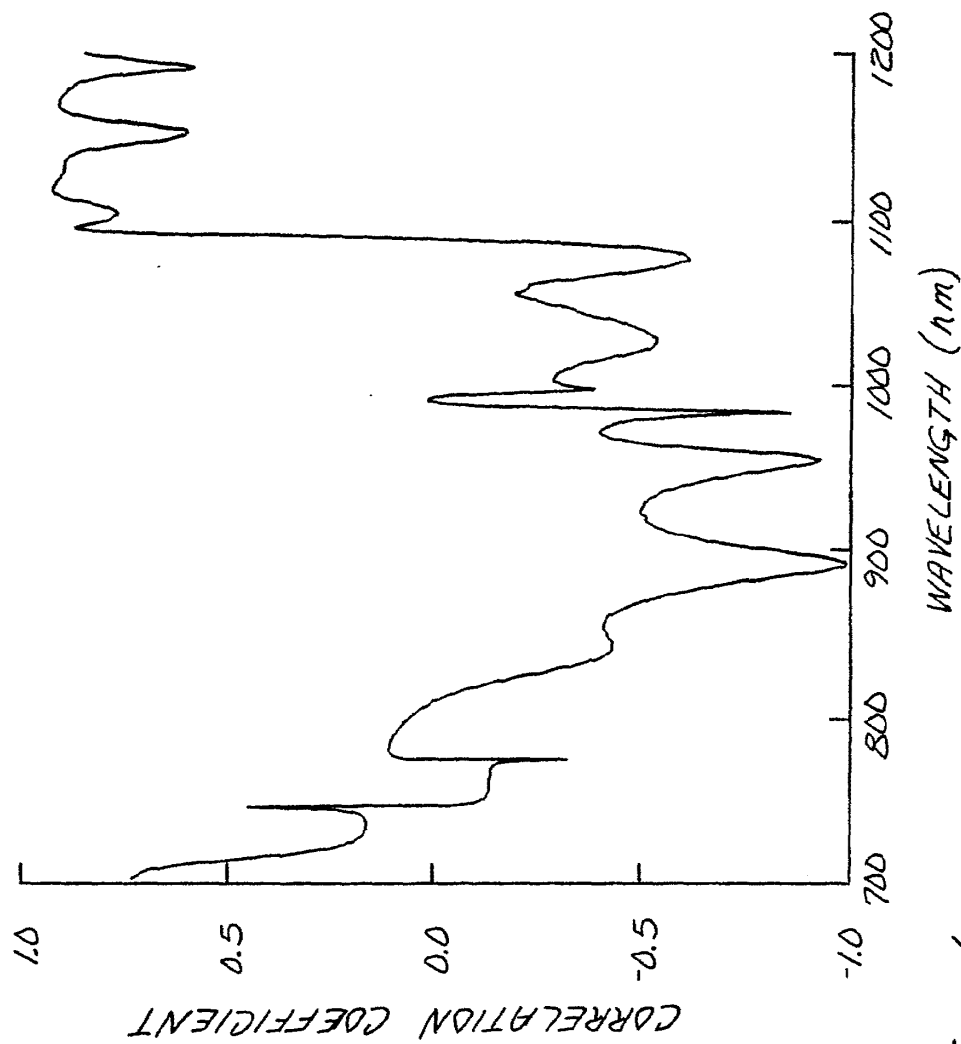


Fig. 6

EP 0 419 223 A2

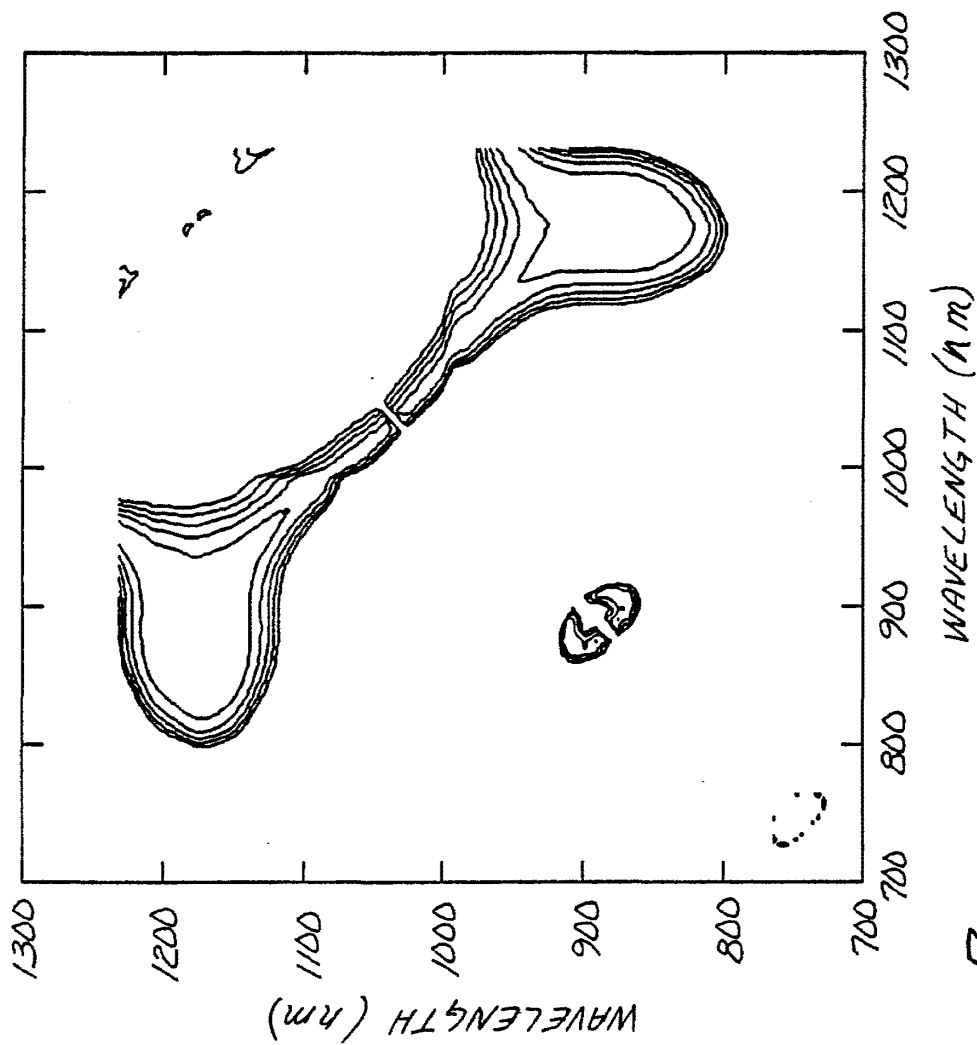


Fig. 7

EP 0 419 223 A2

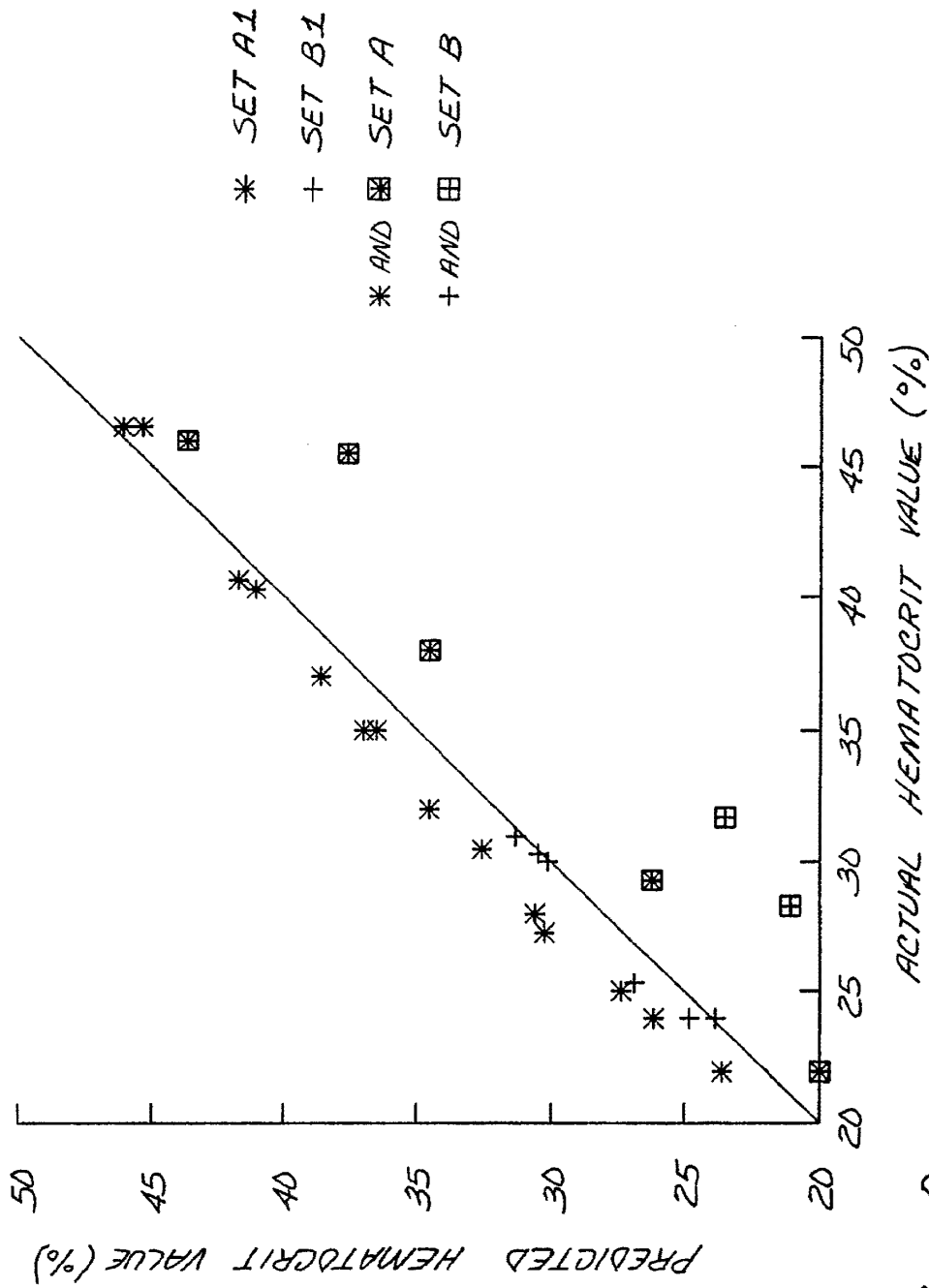


Fig. 8

CX-1622

EP 0 419 223 A2

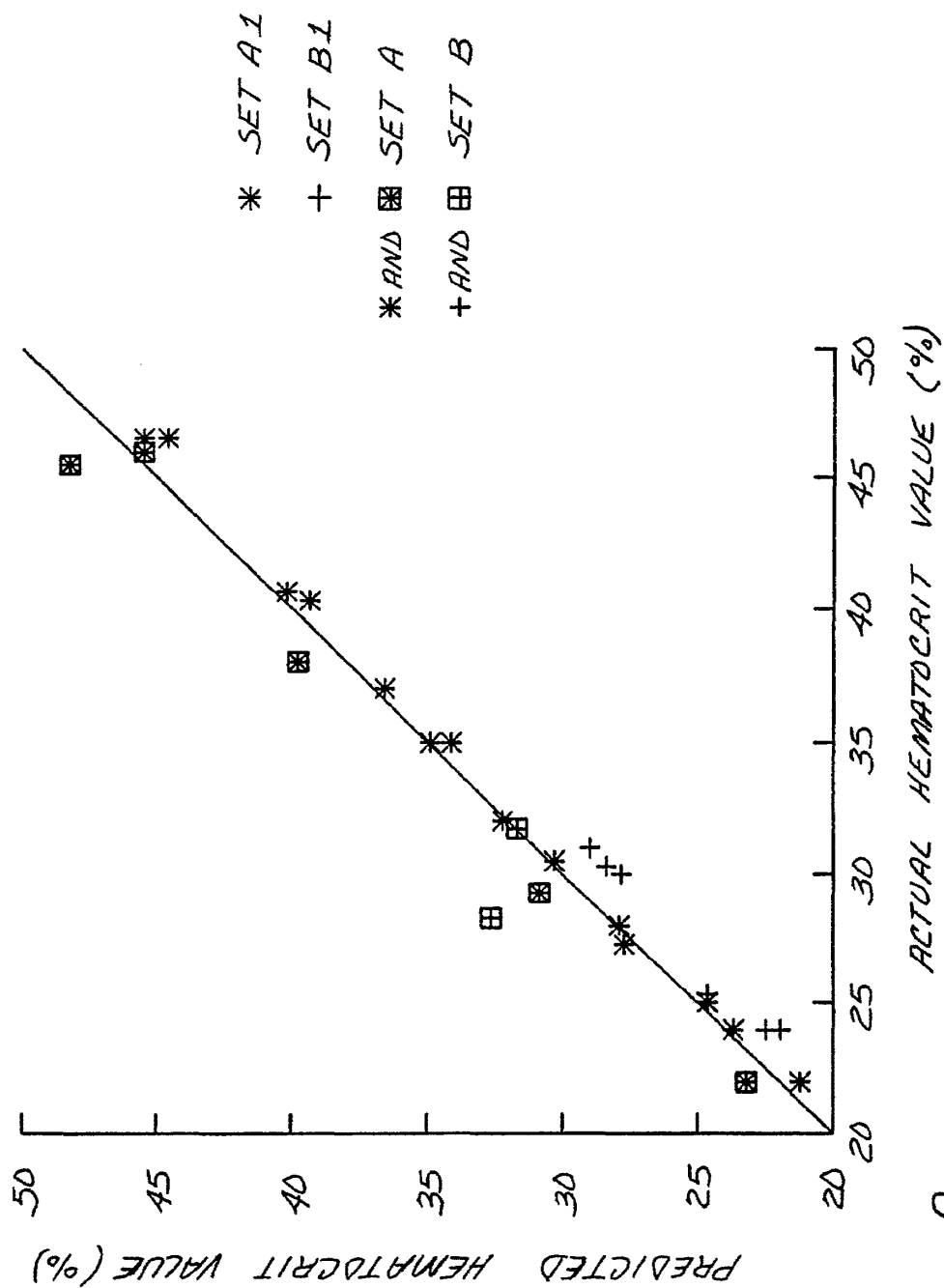
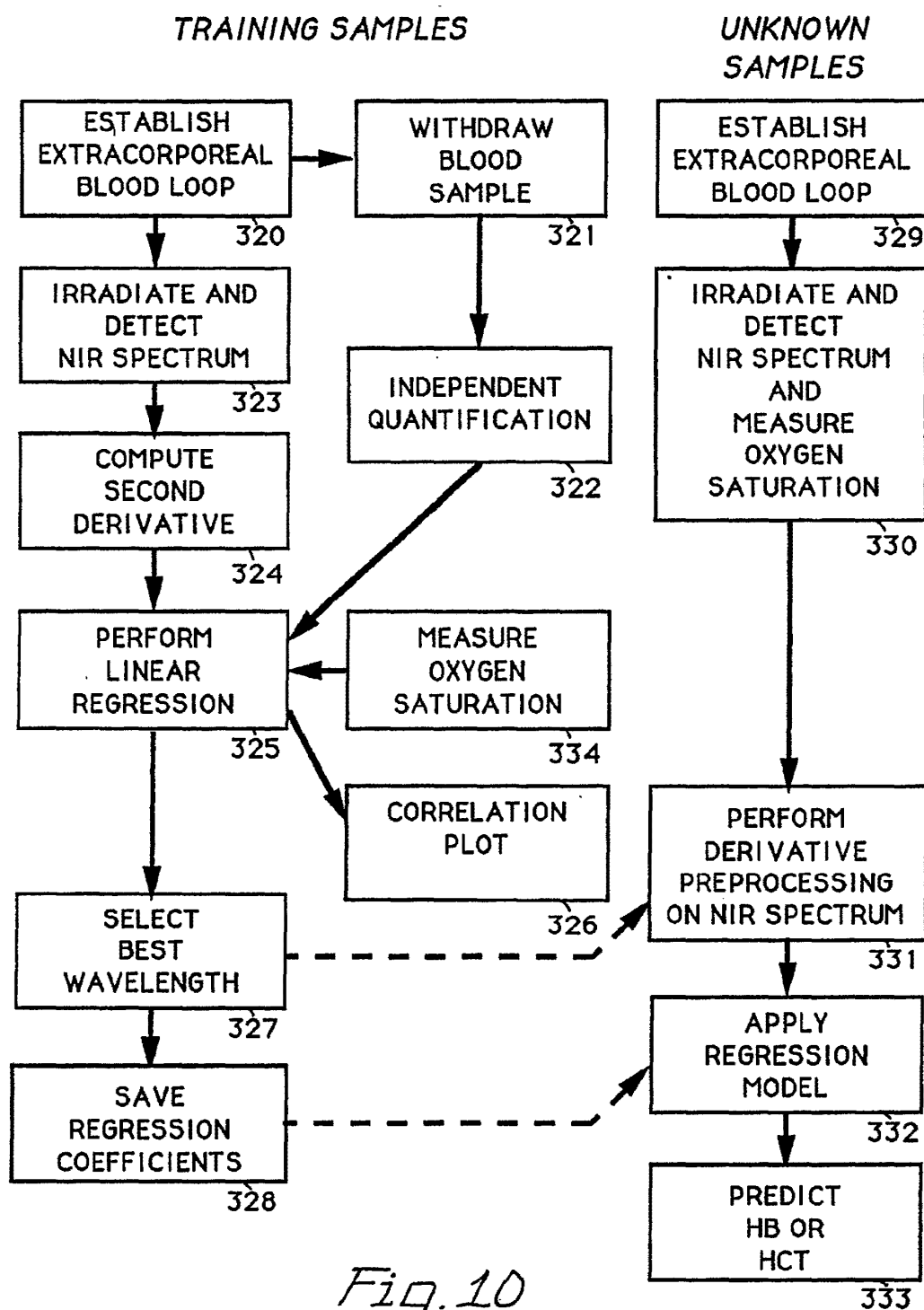
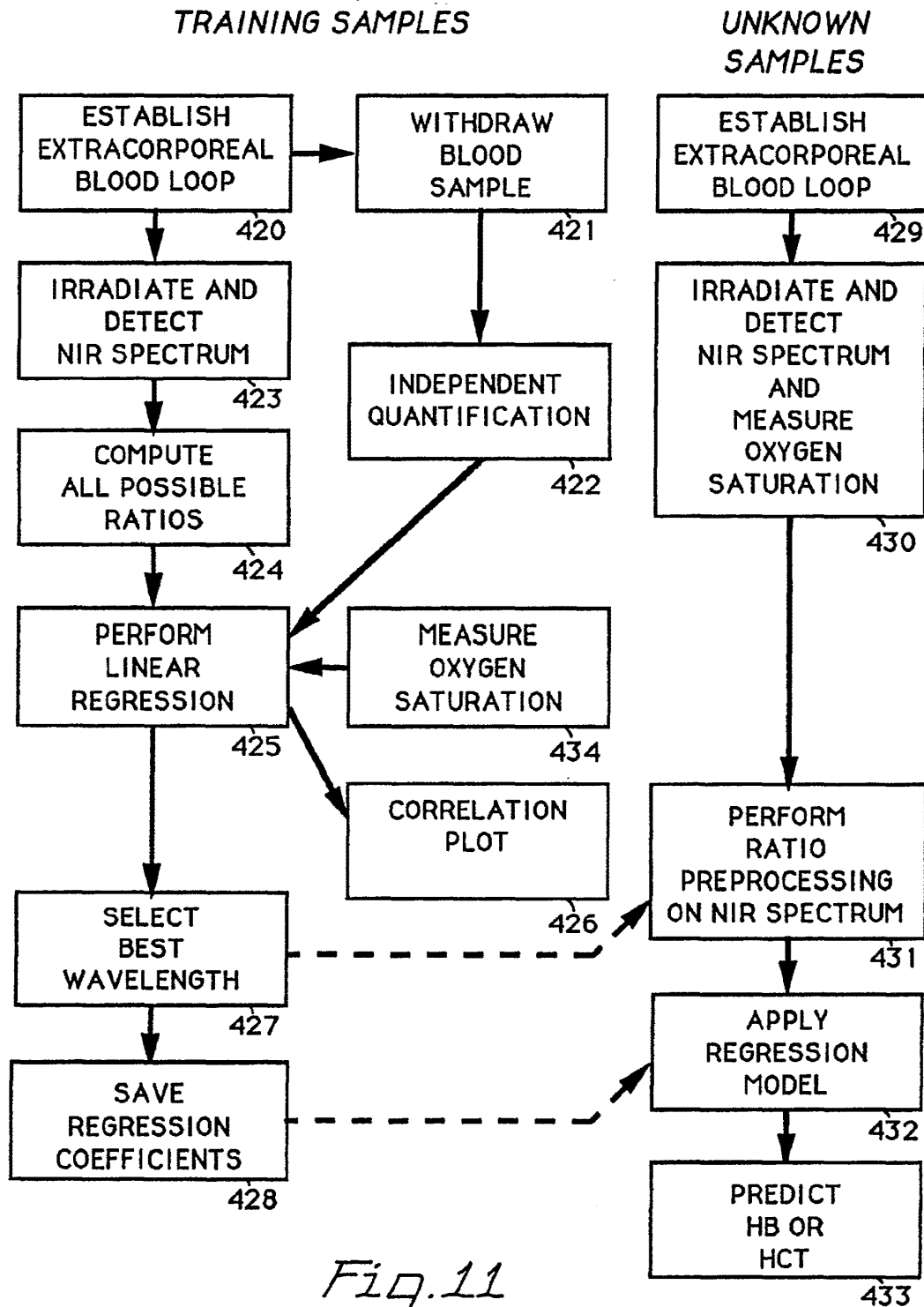


Fig. 9

EP 0 419 223 A2



EP 0 419 223 A2



EP 0 419 223 A2

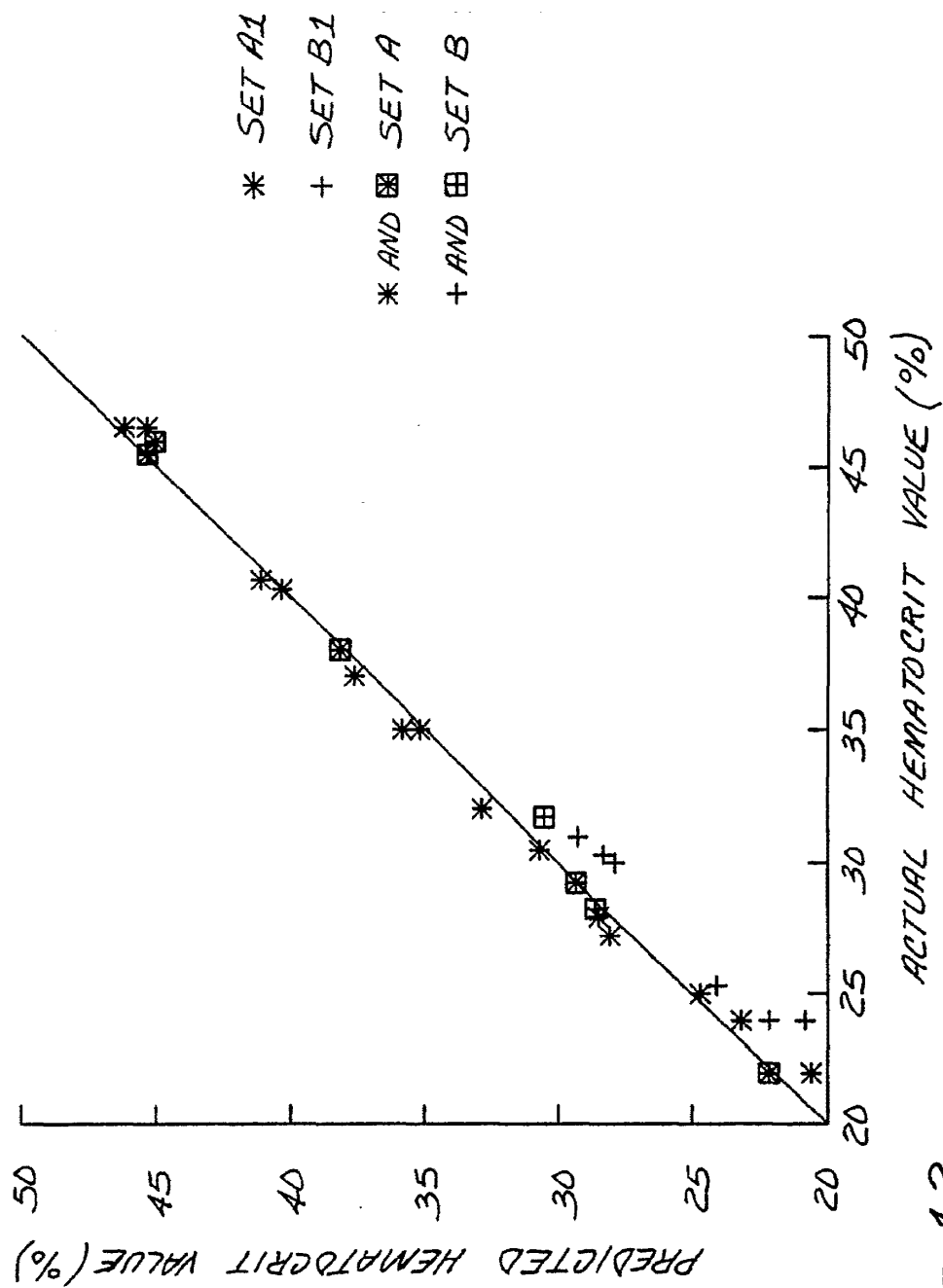


Fig. 12

EP 0 419 223 A2

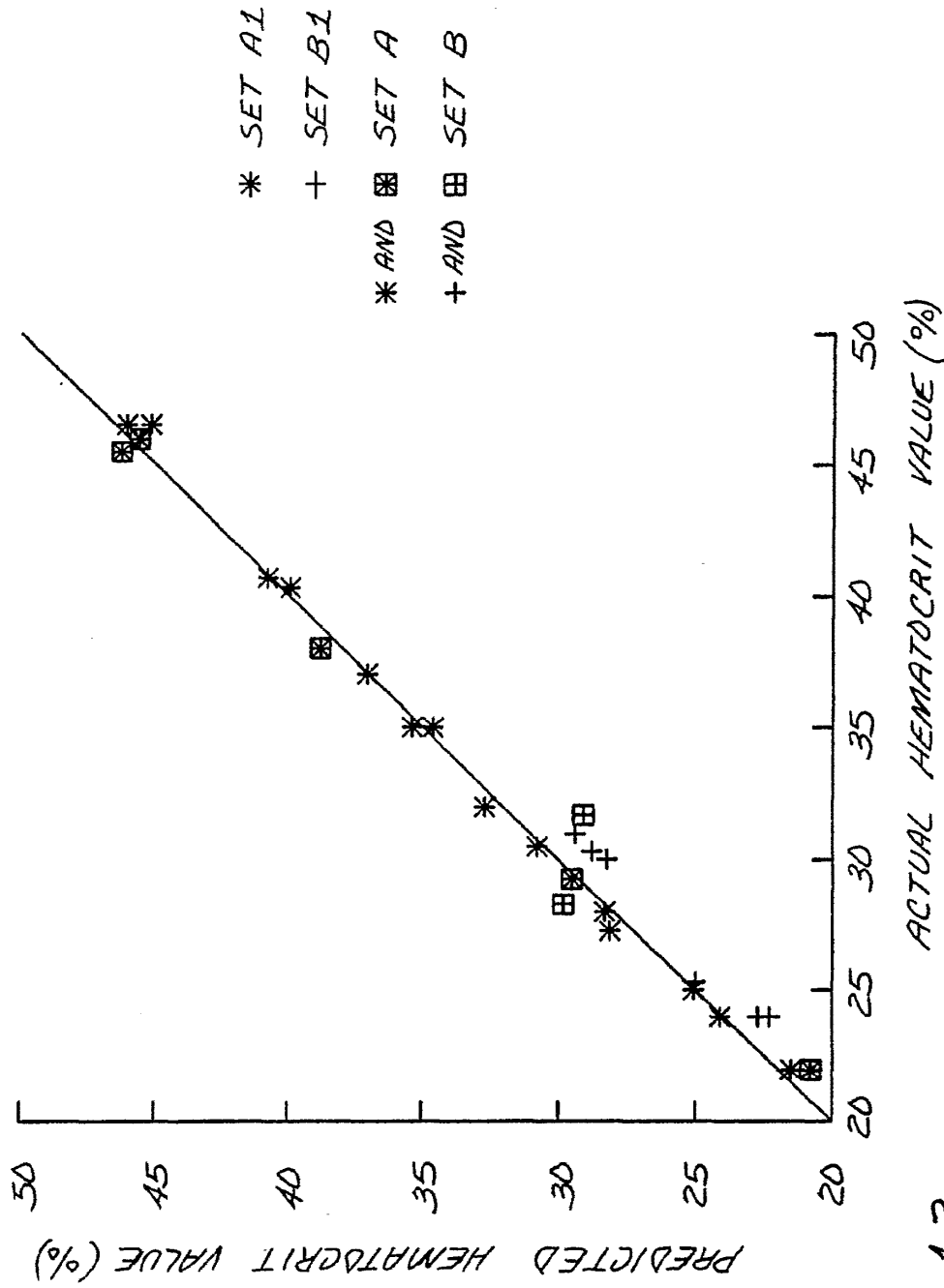


Fig. 13



EP 0 419 223 A2

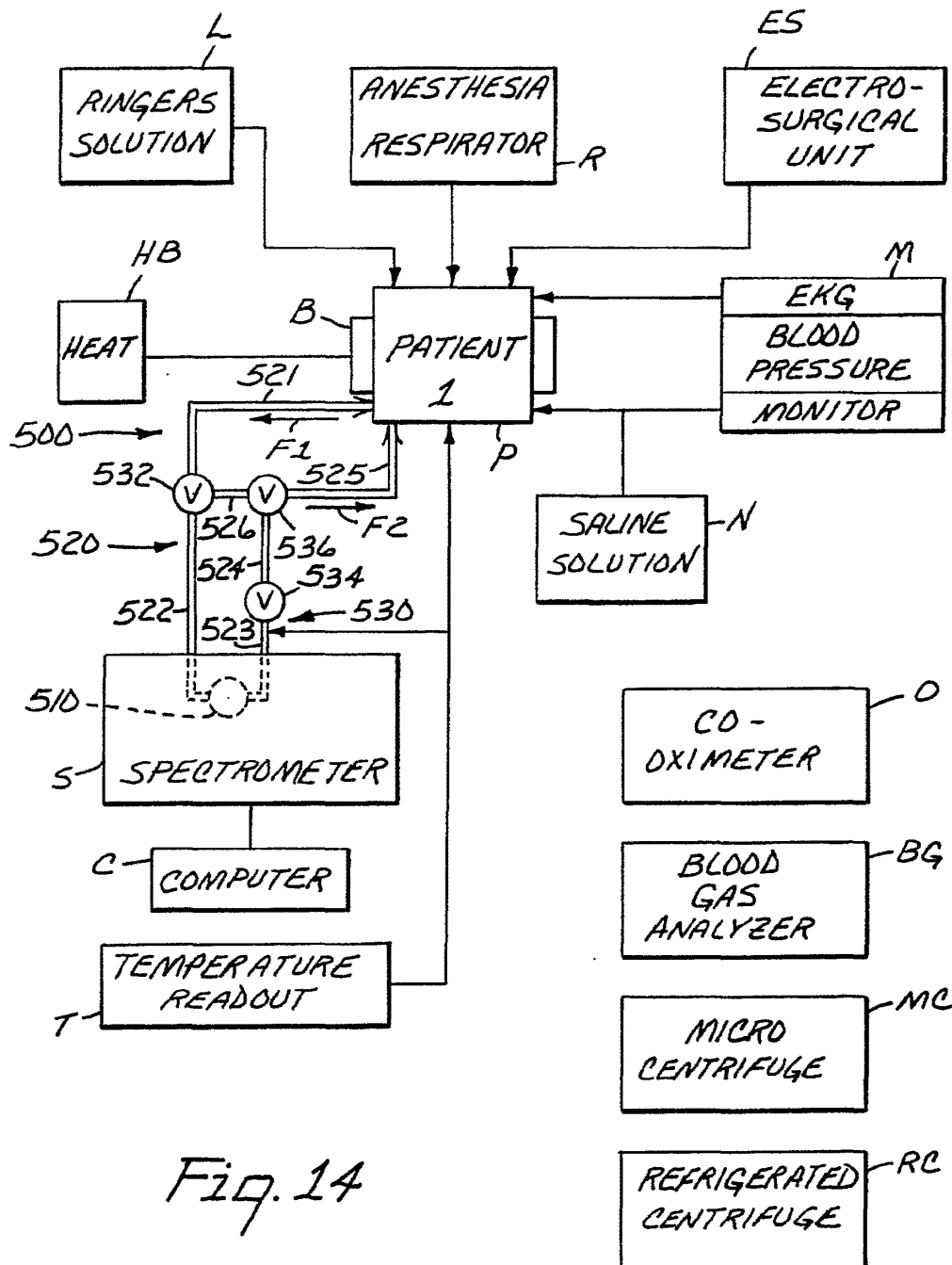


Fig. 14

Docket No.: MLHUM.002C1

Customer No. 20995

**INFORMATION DISCLOSURE STATEMENT**

Applicant : Massi Joe E. Kiani, et al.  
App. No : 12/829,352  
Filed : July 1, 2010  
For : MULTI-STREAM DATA  
COLLECTION SYSTEM FOR  
NONINVASIVE MEASUREMENT OF  
BLOOD CONSTITUENTS  
Examiner : Unknown  
Art Unit : 2877  
Conf No. : 8366

**CERTIFICATE OF EFS WEB  
TRANSMISSION**

I hereby certify that this correspondence, and any other attachment noted on the automated Acknowledgement Receipt, is being transmitted from within the Pacific Time zone to the Commissioner for Patents via the EFS Web server on:

August 11, 2010

(Date)

Jarom D. Kesler, Reg. No. 57,046

Mail Stop Amendment  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

Enclosed for filing in the above-identified application is a PTO/SB/08 Equivalent listing 17 references, of which 9 are enclosed/submitted.

This Information Disclosure Statement is being filed before the receipt of a first Office Action on the merits, and presumably no fee is required. If a first Office Action on the merits was mailed before the mailing date of this Statement, the Commissioner is authorized to charge the fee set forth in 37 C.F.R. § 1.17(p) to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON &amp; BEAR, LLP

Dated: August 11, 2010

By:

Jarom D. Kesler  
Registration No. 57,046  
Attorney of Record  
Customer No. 20995  
(949) 760-0404

9489389



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/829,352	07/01/2010	Massi Joe E. Kiani	MLHUM.002C1

CONFIRMATION NO. 8366

## FORMALITIES LETTER

20995

KNOBBE MARTENS OLSON & BEAR LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614



\*OC000000042628066\*

Date Mailed: 07/22/2010

## NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

*Filing Date Granted***Items Required To Avoid Abandonment:**

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is missing.

*A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.*

*Note: If a petition under 37 CFR 1.47 is being filed, an oath or declaration in compliance with 37 CFR 1.63 signed by all available joint inventors, or if no inventor is available by a party with sufficient proprietary interest, is required.*

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- To avoid abandonment, a surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.16(f) of \$130 for a non-small entity, must be submitted with the missing items identified in this notice.

**SUMMARY OF FEES DUE:**

Total additional fee(s) required for this application is \$130 for a non-small entity

- \$130 Surcharge.

Replies should be mailed to:

Mail Stop Missing Parts  
Commissioner for Patents  
P.O. Box 1450  
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web.

<https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html>

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at <http://www.uspto.gov/ebc>.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

/ddinh/

---

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
12/829,352	07/01/2010	2877	1464	MLHUM.002C1	22	3

CONFIRMATION NO. 8366

20995  
 KNOBBE MARTENS OLSON & BEAR LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

## FILING RECEIPT



\*OC000000042628065\*

Date Mailed: 07/22/2010

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

## Applicant(s)

Massi Joe E. Kiani, Laguna Niguel, CA;  
 Marcelo Lamego, Coto De Caza, CA;  
 Sean Merritt, Lake Forest, CA;  
 Cristiano Dalvi, Mission Viejo, CA;  
 Hung Vo, Garden Grove, CA;  
 Johannes Bruinsma, Mission Viejo, CA;  
 Jeroen Poeze, Mission Viejo, CA;  
 Ferydan Lesmana, Irvine, CA;

Power of Attorney: None

## Domestic Priority data as claimed by applicant

This application is a CON of 12/534,827 08/03/2009  
 which claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/091,732 08/25/2008  
 This application 12/829,352  
 is a CON of 12/497,528 07/02/2009  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008

and is a CIP of 29/323,409 08/25/2008  
 and is a CIP of 29/323,408 08/25/2008 PAT D,606,659  
 This application 12/829,352  
 is a CON of 12/497,523 07/02/2009  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008  
 and is a CIP of 29/323,408 08/25/2008 PAT D,606,659

### Foreign Applications

**If Required, Foreign Filing License Granted:** 07/16/2010

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/829,352**

**Projected Publication Date:** To Be Determined - pending completion of Missing Parts

**Non-Publication Request:** No

**Early Publication Request:** No  
**Title**

MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

### Preliminary Class

356

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application

page 2 of 3

serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

### **LICENSE FOR FOREIGN FILING UNDER**

#### **Title 35, United States Code, Section 184**

#### **Title 37, Code of Federal Regulations, 5.11 & 5.15**

#### **GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

#### **NOT GRANTED**

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

12829352

Docket No.: MLHUM.002C1

Customer No. 20995

## INFORMATION DISCLOSURE STATEMENT

Applicants : Massi Joe E. Kiani et al.  
 App. No : Unknown  
 Filed : Herewith  
 For : MULTI-STREAM DATA  
 COLLECTION SYSTEM FOR  
 NONINVASIVE MEASUREMENT  
 OF BLOOD CONSTITUENTS  
 Examiner : Unknown  
 Art Unit : Unknown  
 Conf No. : Unknown

CERTIFICATE OF EFS WEB  
TRANSMISSION

I hereby certify that this correspondence,  
 and any other attachment noted on the  
 automated Acknowledgement Receipt, is  
 being transmitted from within the Pacific  
 Time zone to the Commissioner for Patents  
 via the EFS Web server on:

July 1, 2010

(Date)

John M. Grover, Reg. No. 42,610

Commissioner for Patents  
 P.O. Box 1450  
 Alexandria, VA 22313-1450

Dear Sir:

Enclosed is a PTO/SB/08 Equivalent listing 249 references that are of record in U.S. patent application No. 12/497,528, filed July 2, 2009, which is the parent of this continuation application, and is relied upon for an earlier filing date under 35 U.S.C. § 120. Copies of the references are not submitted pursuant to 37 C.F.R. § 1.98(d).

This Information Disclosure Statement is being filed within three months of the filing date, with an RCE or before receipt of a first office action after an RCE and no fee is required.

The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment, to Account No. 11-1410.

07/19/2010 VVAN11 00000003 111410 12829352

01 FC:1011 330.00 DA  
 02 FC:1111 540.00 DA  
 03 FC:1311 220.00 DA  
 04 FC:1081 270.00 DA  
 05 FC:1202 104.00 DA

Dated: July 1, 2010

Respectfully submitted,

KNOBBE, MARTENS, OLSON &amp; BEAR, LLP

By:

John M. Grover  
 Registration No. 42,610  
 Attorney of Record  
 Customer No. 20995  
 (949) 760-0404

9288147/070110



CX-1622

<b>Electronic Acknowledgement Receipt</b>	
<b>EFS ID:</b>	7943198
<b>Application Number:</b>	12829352
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	8366
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Massl Joe E. Kiani
<b>Customer Number:</b>	20995
<b>Filer:</b>	John M. Grover/Quyen Lieu
<b>Filer Authorized By:</b>	John M. Grover
<b>Attorney Docket Number:</b>	MLHUM.002C1
<b>Receipt Date:</b>	01-JUL-2010
<b>Filing Date:</b>	
<b>Time Stamp:</b>	21:27:42
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment		no			
<b>File Listing:</b>					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ADS_MLHUM002C1.pdf	512067 1071ab3a8596793631ace672d9051e833cf28880	no	9
<b>Warnings:</b>					
<b>Information:</b>					

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Massi Joe E. Kiani et al.
	Art Unit	Unknown
(Multiple sheets used when necessary)		Examiner
SHEET 1 OF 9		Attorney Docket No. MLHUM.002C1

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	7,734,320	06/2010	Al-Ali	
	2	7,729,733	06/2010	Al-Ali et al.	
	3	RE41,317	05/2010	Parker	
	4	D614,305	04/2010	Al-Ali et al.	
	5	D609,193	02/2010	Al-Ali et al.	
	6	7,647,083	01/2010	Al-Ali et al.	
	7	D606,659	12/2009	Kiani et al.	
	8	7,618,375	11/2009	Flaherty	
	9	2009-0259114	10/2009	Johnson et al.	
	10	7,596,398	09/2009	Al-Ali et al.	
	11	7,563,110	07/2009	Al-Ali et al.	
	12	7,530,955	05/2009	Diab et al.	
	13	7,530,949	05/2009	Al Ali et al.	
	14	7,530,942	05/2009	Diab	
	15	7,526,328	04/2009	Diab et al.	
	16	7,510,849	03/2009	Schurman et al.	
	17	7,509,494	03/2009	Al-Ali	
	18	7,509,154	03/2009	Diab et al.	
	19	7,500,950	03/2009	Al-Ali et al.	
	20	D587,657	03/2009	Al-Ali et al.	
	21	7,499,835	03/2009	Weber et al.	
	22	7,499,741	03/2009	Diab et al.	
	23	7,496,393	02/2009	Diab et al.	
	24	7,496,391	02/2009	Diab et al.	
	25	7,489,958	02/2009	Diab et al.	
	26	7,483,730	01/2009	Diab et al.	
	27	7,483,729	01/2009	Al-Ali et al.	
	28	7,471,971	12/2008	Diab et al.	
	29	7,471,969	12/2008	Diab et al.	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Massi Joe E. Kiani et al.
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 2 OF 9	Attorney Docket No.	MLHUM.002C1

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	7,469,157	12/2008	Diab et al.	
	31	7,467,002	12/2008	Weber et al.	
	32	7,454,240	11/2008	Diab et al.	
	33	7,440,787	10/2008	Diab	
	34	7,438,683	10/2008	Al-Ali et al.	
	35	7,428,432	09/2008	Ali et al.	
	36	7,415,297	08/2008	Al-Ali et al.	
	37	7,383,070	06/2008	Diab et al.	
	38	7,377,899	05/2008	Weber et al.	
	39	7,377,794	05/2008	Al Ali et al.	
	40	7,376,453	05/2008	Diab et al.	
	41	7,373,194	05/2008	Weber et al.	
	42	7,373,193	05/2008	Al-Ali et al.	
	43	7,371,981	05/2008	Abdul-Hafiz	
	44	7,356,365	04/2009	Schurman	
	45	D566,282	04/2008	Al-Ali et al.	
	46	7,355,512	04/2008	Al-Ali	
	47	7,343,186	03/2008	Lamego et al.	
	48	7,341,559	03/2008	Schulz et al.	
	49	7,340,287	03/2008	Mason et al.	
	50	7,332,784	02/2008	Mills, et al.	
	51	7,328,053	02/2008	Diab et al.	
	52	7,295,866	11/2007	Al-Ali	
	53	7,292,883	11/2007	De Felice et al.	
	54	D554,263	10/2007	Al-Ali	
	55	7,289,835	10/2007	Mansfield et al.	
	56	7,280,858	10/2007	Al-Ali et al.	
	57	7,274,955	09/2007	Kiani et al.	
	58	7,272,425	09/2007	Al-Ali	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Massi Joe E. Kiani et al.
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 3 OF 9	Attorney Docket No.	MLHUM.002C1

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	7,254,434	08/2007	Schulz et al.	
	60	7,254,433	08/2007	Diab et al.	
	61	7,254,431	08/2007	Al-Ali	
	62	7,254,429	08/2007	Schurman et al.	
	63	7,245,953	07/2007	Parker	
	64	7,239,905	07/2007	Kiani-Azarbayjany et al.	
	65	RE39,672	06/2007	Shehada et al.	
	66	7,225,007	05/2007	Al-Ali	
	67	7,225,006	05/2007	Al-Ali et al.	
	68	7,221,971	05/2007	Diab	
	69	7,215,986	05/2007	Diab	
	70	7,215,984	05/2007	Diab	
	71	7,190,261	03/2007	Al-Ali	
	72	7,186,966	03/2007	Al-Ali	
	73	7,149,561	12/2006	Diab	
	74	7,142,901	11/2006	Kiani et al.	
	75	7,132,641	11/2006	Schulz et al.	
	76	2006-211924	09/2006	David Dalke, et al.	
	77	7,096,054	08/2006	Abdul-Hafiz et al.	
	78	7,096,052	08/2006	Mason et al.	
	79	7,067,893	06/2006	Mills et al.	
	80	7,044,918	05/2006	Diab	
	81	7,041,060	05/2006	Flaherty et al	
	82	7,039,449	05/2006	Al-Ali	
	83	7,030,749	04/2006	Al-Ali	
	84	7,027,849	04/2006	Al-Ali	
	85	7,024,233	04/2006	Ali et al.	
	86	7,015,451	02/2006	Dalke et al.	
	87	7,003,339	02/2006	Diab et al.	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Massi Joe E. Kiani et al.
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 4 OF 9	Attorney Docket No.	MLHUM.002C1

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	7,003,338	02/2006	Weber et al.	
	89	6,999,904	02/2006	Weber et al.	
	90	6,996,427	02/2006	Ali et al.	
	91	6,993,371	01/2006	Kiani et al.	
	92	6,985,764	01/2006	Mason et al.	
	93	6,979,812	12/2005	Al-Ali	
	94	6,970,792	11/2005	Diab	
	95	6,961,598	11/2005	Diab	
	96	6,950,687	09/2005	Al-Ali	
	97	6,943,348	09/2005	Coffin IV	
	98	6,939,305	09/2005	Flaherty et al.	
	99	6,934,570	08/2005	Kiani et al.	
	100	6,931,268	08/2005	Kiani-Azarbayjany et al.	
	101	6,920,345	07/2005	Al-Ali et al.	
	102	6,898,452	05/2005	Al-Ali et al.	
	103	6,861,639	03/2005	Al-Ali	
	104	6,852,083	02/2005	Caro et al.	
	105	6,850,788	02/2005	Al-Ali	
	106	6,850,787	02/2005	Weber et al.	
	107	6,830,711	12/2004	Mills et al.	
	108	6,826,419	11/2004	Diab et al.	
	109	6,822,564	11/2004	Al-Ali	
	110	6,816,741	11/2004	Diab	
	111	6,813,511	11/2004	Diab et al.	
	112	6,792,300	09/2004	Diab et al.	
	113	6,771,994	08/2004	Kiani et al.	
	114	6,770,028	08/2004	Ali et al.	
	115	6,760,607	07/2004	Al-Ali	
	116	6,745,060	06/2004	Diab et al.	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Massi Joe E. Kiani et al.
	Art Unit	Unknown
(Multiple sheets used when necessary)		Examiner
SHEET 5 OF 9		Attorney Docket No. MLHUM.002C1

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	117	6,735,459	05/2004	Parker	
	118	6,728,560	04/2004	Kollias, et al.	
	119	6,725,075	04/2004	Al-Ali	
	120	6,721,585	04/2004	Parker	
	121	6,721,582	04/2004	Trepagnier, et al.	
	122	RE38,492	04/2004	Diab et al.	
	123	6,714,804	03/2004	Al-Ali et al.	
	124	RE38,476	03/2004	Diab et al.	
	125	2004-054291	03/2004	Christian Schulz, et al.	
	126	6,699,194	03/2004	Diab et al.	
	127	6,697,658	02/2004	Al-Ali	
	128	6,697,657	02/2004	Shehada, et al.	
	129	6,697,656	02/2004	Al-Ali	
	130	6,684,091	01/2004	Parker	
	131	6,684,090	01/2004	Ali et al.	
	132	6,678,543	01/2004	Diab et al.	
	133	6,671,531	12/2003	Al-Ali et al.	
	134	6,661,161	12/2003	Lanzo et al.	
	135	6,658,276	12/2003	Diab et al.	
	136	6,654,624	11/2003	Diab et al.	
	137	6,650,917	11/2003	Diab et al.	
	138	6,643,530	11/2003	Diab et al.	
	139	6,640,116	10/2003	Diab	
	140	6,639,668	10/2003	Trepagnier, Pierre	
	141	6,632,181	10/2003	Flaherty et al.	
	142	6,606,511	08/2003	Ali et al.	
	143	6,597,933	07/2003	Kiani et al.	
	144	6,597,932	07/2003	Tian et al.	
	145	6,595,316	07/2003	Cybulski et al.	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Massi Joe E. Kiani et al.
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 6 OF 9	Attorney Docket No.	MLHUM.002C1

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	146	6,584,336	06/2003	Ali et al.	
	147	6,580,086	06/2003	Schulz et al.	
	148	6,542,764	04/2003	Al-Ali et al.	
	149	6,541,756	04/2003	Schulz et al.	
	150	6,526,300	02/2003	Kiani et al.	
	151	6,525,386	02/2003	Mills et al.	
	152	6,519,487	02/2003	Parker	
	153	6,515,273	02/2003	Al-Ali	
	154	6,505,059	01/2003	Kollias, et al.	
	155	6,501,975	12/2002	Diab et al.	
	156	6,470,199	10/2002	Kopotic et al.	
	157	6,463,311	10/2002	Diab	
	158	6,430,525	08/2002	Weber et al.	
	159	6,397,091	05/2002	Diab et al.	
	160	6,388,240	05/2002	Schulz et al.	
	161	6,377,829	04/2002	Al-Ali	
	162	6,371,921	04/2002	Caro et al.	
	163	6,368,283	04/2002	Xu, et al.	
	164	6,360,115	03/2002	Roger Greenwald, et al.	
	165	6,360,114	03/2002	Diab et al.	
	166	6,349,228	02/2002	Kiani et al.	
	167	6,345,194	02/2002	Robert Nelson, et al.	
	168	6,343,224	01/2002	Parker	
	169	6,334,065	12/2001	Al-Ali et al.	
	170	6,321,100	11/2001	Parker	
	171	6,285,896	09/2001	Tobler et al.	
	172	6,280,213	08/2001	Tobler et al.	
	173	6,278,522	08/2001	Lepper, Jr. et al.	
	174	6,263,222	07/2001	Diab et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Massi Joe E. Kiani et al.
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 7 OF 9	Attorney Docket No.	MLHUM.002C1

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	175	6,256,523	07/2001	Diab et al.	
	176	6,241,683	06/2001	Macklem, et al.	
	177	6,236,872	05/2001	Diab et al.	
	178	6,232,609	05/2001	Snyder, et al.	
	179	6,229,856	05/2001	Diab et al.	
	180	6,206,830	03/2001	Diab et al.	
	181	6,184,521	02/2001	Coffin, IV et al.	
	182	6,165,005	12/2000	Mills et al.	
	183	6,157,850	12/2000	Diab et al.	
	184	6,152,754	11/2000	Gerhardt et al.	
	185	6,151,516	11/2000	Kiani-Azarbayjany et al.	
	186	6,144,868	11/2000	Parker	
	187	6,124,597	09/2000	Shehada	
	188	6,110,522	08/2000	Lepper, Jr. et al.	
	189	6,088,607	07/2000	Diab et al.	
	190	6,081,735	06/2000	Diab et al.	
	191	6,067,462	05/2000	Diab et al.	
	192	6,045,509	04/2000	Caro et al.	
	193	6,036,642	03/2000	Diab et al.	
	194	6,027,452	02/2000	Flaherty et al.	
	195	6,011,986	01/2000	Diab et al.	
	196	6,002,952	12/1999	Diab et al.	
	197	5,997,343	12/1999	Mills et al.	
	198	5,995,855	11/1999	Kiani et al.	
	199	5,940,182	08/1999	Lepper, Jr. et al.	
	200	5,934,925	08/1999	Tobler et al.	
	201	5,919,134	07/1999	Diab	
	202	5,904,654	05/1999	Wohltmann et al.	
	203	5,890,929	04/1999	Mills et al.	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Massi Joe E. Kiani et al.
	Art Unit	Unknown
SHEET 8 OF 9		Attorney Docket No. MLHUM.002C1

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	204	5,860,919	01/1999	Kiani-Azarbayjany et al.	
	205	5,833,618	11/1998	Caro et al.	
	206	5,830,131	11/1998	Caro et al.	
	207	5,823,950	10/1998	Diab et al.	
	208	5,810,734	09/1998	Caro et al.	
	209	5,791,347	08/1998	Flaherty et al.	
	210	5,785,659	07/1998	Caro et al.	
	211	5,782,757	07/1998	Diab et al.	
	212	5,769,785	06/1998	Diab et al.	
	213	5,760,910	06/1998	Lepper, Jr. et al.	
	214	5,758,644	06/1998	Diab et al.	
	215	5,743,262	04/1998	Lepper, Jr. et al.	
	216	Des. 393,830	04/1998	Tobler et al.	
	217	5,685,299	11/1997	Diab et al.	
	218	5,645,440	07/1997	Tobler et al.	
	219	5,638,818	06/1997	Diab et al.	
	220	5,638,816	06/1997	Kiani-Azarbayjany et al.	
	221	5,632,272	05/1997	Diab et al.	
	222	5,602,924	02/1997	Durand et al.	
	223	5,590,649	01/1997	Caro et al.	
	224	5,562,002	10/1986	Lalin	
	225	5,561,275	10/1996	Savage, et al.	
	226	5,533,511	07/1996	Kaspari et al.	
	227	5,494,043	02/1996	O'Sullivan et al.	
	228	5,490,505	02/1996	Diab et al.	
	229	5,482,036	01/1996	Diab et al.	
	230	D363,120	10/1995	Savage et al.	
	231	5,456,252	10/1995	Vari, et al.	
	232	5,452,717	09/1995	Branigan et al.	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Massi Joe E. Kiani et al.
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 9 OF 9	Attorney Docket No.	MLHUM.002C1

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	233	D362,063	09/1995	Savage et al.	
	234	D361,840	08/1995	Savage et al.	
	235	D359,546	06/1995	Savage, et al.	
	236	5,431,170	07/1995	Mathews	
	237	D353,196	12/1994	Savage et al.	
	238	D353,195	12/1994	Savage et al.	
	239	5,278,627	01/1994	Aoyagi et al.	
	240	5,377,676	01/1995	Vari, et al.	
	241	5,341,805	08/1994	Stavridi, et al.	
	242	5,337,744	08/1994	Branigan	
	243	5,163,438	11/1992	Gordon et al.	
	244	5,069,213	12/1991	Polczynski	
	245	5,041,187	08/1991	Hink et al.	
	246	4,964,408	10/1990	Hink et al.	
	247	4,960,128	10/1990	Gordon et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document Country Code-Number-Kind Code Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T <sup>1</sup>
	248	WO93/12712	07/1993	Vivascan Corp		

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	249	International Search Report and Written Opinion for PCT/US2009/049638, mailed January 7, 2010.	

9287890  
070110

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

Page 931 of 1082

Appx59209

CX-1622

Electronic Acknowledgement Receipt	
<b>EFS ID:</b>	7943198
<b>Application Number:</b>	12829352
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	8366
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Massi Joe E. Kiani
<b>Customer Number:</b>	20995
<b>Filer:</b>	John M. Grover/Quyen Lieu
<b>Filer Authorized By:</b>	John M. Grover
<b>Attorney Docket Number:</b>	MLHUM.002C1
<b>Receipt Date:</b>	01-JUL-2010
<b>Filing Date:</b>	
<b>Time Stamp:</b>	21:27:42
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	no
------------------------	----

**File Listing:**

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ADS_MLHUM002C1.pdf	512067 1071ab3a8598793631ace672d9051e833cf28880	no	9

**Warnings:****Information:**

CX-1622

This is not an USPTO supplied ADS fillable form					
2		Specification_MLHUM002C1.pdf	3680002 9a443a09cd5f923befc4775e695435aeb63d1d6	yes	70
	<b>Multipart Description/PDF files in .zip description</b>				
	<b>Document Description</b>		<b>Start</b>	<b>End</b>	
	Specification		1	66	
	Claims		67	69	
	Abstract		70	70	
<b>Warnings:</b>					
<b>Information:</b>					
3	Drawings-only black and white line drawings	Drawings_MLHUM002C1.PDF	1408561 a8a858ebcd373015b7007b4faf3040dca1a939e0	no	65
<b>Warnings:</b>					
<b>Information:</b>					
4		IDS_MLHUM002C1.pdf	537323 5be8a9f86e9837d33b3e98a4ced6a567e777df3	yes	10
	<b>Multipart Description/PDF files in .zip description</b>				
	<b>Document Description</b>		<b>Start</b>	<b>End</b>	
	Transmittal Letter		1	1	
	Information Disclosure Statement (IDS) Filed (SB/08)		2	10	
<b>Warnings:</b>					
<b>Information:</b>					
<b>Total Files Size (in bytes):</b>			6137953		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/14 (07-07)

Approved for use through 06/30/2010. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MLHUM.002C1
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
<p>The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.</p> <p>This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.</p>			

**Secrecy Order 37 CFR 5.2**

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

**Applicant Information:**

<b>Applicant 1</b>				
<b>Applicant Authority</b>		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117
		<input type="radio"/> Party of Interest under 35 U.S.C. 118		
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>
	Massi Joe	E.	Kiani	
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service				
<b>City</b>	Laguna Niguel	<b>State/Province</b>	CA	<b>Country of Residence</b> US
<b>Citizenship under 37 CFR 1.41(b)</b>		US		
<b>Mailing Address of Applicant:</b>				
<b>Address 1</b>	35 Brindisi			
<b>Address 2</b>				
<b>City</b>	Laguna Niguel	<b>State/Province</b>	CA	
<b>Postal Code</b>	92677	<b>Country</b>	US	
<b>Applicant 2</b>				
<b>Applicant Authority</b>		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117
		<input type="radio"/> Party of Interest under 35 U.S.C. 118		
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>
	Marcelo		Lamego	
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service				
<b>City</b>	Coto De Caza	<b>State/Province</b>	CA	<b>Country of Residence</b> US
<b>Citizenship under 37 CFR 1.41(b)</b>		BR		
<b>Mailing Address of Applicant:</b>				
<b>Address 1</b>	18 Lyra Way			
<b>Address 2</b>				
<b>City</b>	Coto De Caza	<b>State/Province</b>	CA	
<b>Postal Code</b>	92679	<b>Country</b>	US	
<b>Applicant 3</b>				
<b>Applicant Authority</b>		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117
		<input type="radio"/> Party of Interest under 35 U.S.C. 118		
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>
	Sean		Merritt	
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service				
<b>City</b>	Lake Forest	<b>State/Province</b>	CA	<b>Country of Residence</b> US

PTO/SB/14 (07-07)

Approved for use through 06/30/2010. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number		MLHUM.002C1	
		Application Number			
Title of Invention		MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS			

Citizenship under 37 CFR 1.41(b)		US			
Mailing Address of Applicant:					
Address 1		22273 Vista Verde Drive			
Address 2					
City	Lake Forest		State/Province	CA	
Postal Code	92630		Country	US	
Applicant 4					
Applicant Authority		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117	
				<input type="radio"/> Party of Interest under 35 U.S.C. 118	
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Cristiano		Dalvi		
Residence Information (Select One) <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Mission Viejo	State/Province	CA	Country of Residence	US
Citizenship under 37 CFR 1.41(b)		BR			
Mailing Address of Applicant:					
Address 1		21622 Marguerite Pkwy, #6			
Address 2					
City	Mission Viejo		State/Province	CA	
Postal Code	92692		Country	US	
Applicant 5					
Applicant Authority		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117	
				<input type="radio"/> Party of Interest under 35 U.S.C. 118	
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Hung		Vo		
Residence Information (Select One) <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Garden Grove	State/Province	CA	Country of Residence	US
Citizenship under 37 CFR 1.41(b)		US			
Mailing Address of Applicant:					
Address 1		8801 Mays Ave.			
Address 2					
City	Garden Grove		State/Province	CA	
Postal Code	92844		Country	CA	
Applicant 6					
Applicant Authority		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117	
				<input type="radio"/> Party of Interest under 35 U.S.C. 118	
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Johannes		Bruinsma		
Residence Information (Select One) <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Mission Viejo	State/Province	CA	Country of Residence	US
Citizenship under 37 CFR 1.41(b)		NL			

PTO/SB/14 (07-07)

Approved for use through 06/30/2010. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MLHUM.002C1
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

<b>Mailing Address of Applicant:</b>				
<b>Address 1</b>		27141 Valia		
<b>Address 2</b>				
<b>City</b>	Mission Viejo	<b>State/Province</b>	CA	
<b>Postal Code</b>	92691	<b>Country</b>	US	
<b>Applicant 7</b>				
<b>Applicant Authority</b>		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117
				<input type="radio"/> Party of Interest under 35 U.S.C. 118
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>
	Jeroen		Poeze	
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service				
<b>City</b>	Mission Viejo	<b>State/Province</b>	CA	<b>Country of Residence</b>
				US
<b>Citizenship under 37 CFR 1.41(b)</b>		NL		
<b>Mailing Address of Applicant:</b>				
<b>Address 1</b>		21622 Marguerite Parkway, #342		
<b>Address 2</b>				
<b>City</b>	Mission Viejo	<b>State/Province</b>	CA	
<b>Postal Code</b>	92692	<b>Country</b>	US	
<b>Applicant 8</b>				
<b>Applicant Authority</b>		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117
				<input type="radio"/> Party of Interest under 35 U.S.C. 118
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>
	Ferydan		Lesmana	
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service				
<b>City</b>	Irvine	<b>State/Province</b>	CA	<b>Country of Residence</b>
				US
<b>Citizenship under 37 CFR 1.41(b)</b>		ID		
<b>Mailing Address of Applicant:</b>				
<b>Address 1</b>		42 New Season		
<b>Address 2</b>				
<b>City</b>	Irvine	<b>State/Province</b>	CA	
<b>Postal Code</b>	92602	<b>Country</b>	US	
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the <b>Add</b> button.				

**Correspondence Information:**

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).	
<input type="checkbox"/> An Address is being provided for the correspondence Information of this application.	
<b>Customer Number</b>	20995
<b>Email Address</b>	efiling@kmob.com
	<input type="button" value="Add Email"/> <input type="button" value="Remove Email"/>



PTO/SB/14 (07-07)

Approved for use through 06/30/2010. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MLHUM.002C1
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

**Application Information:**

Title of the Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
Attorney Docket Number	MLHUM.002C1	Small Entity Status Claimed	<input type="checkbox"/>
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	65	Suggested Figure for Publication (if any)	1

**Publication Information:**

<input type="checkbox"/>	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
<input type="checkbox"/>	<b>Request Not to Publish.</b> I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application <b>has not and will not</b> be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

**Representative Information:**

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.			
Please Select One:	<input checked="" type="radio"/> Customer Number	<input type="radio"/> US Patent Practitioner	<input type="radio"/> Limited Recognition (37 CFR 11.9)
Customer Number	20995		

**Domestic Benefit/National Stage Information:**

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.			
Prior Application Status	Pending	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	12/534827	2009-08-03
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086108	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	

CX-1622

PTO/SB/14 (07-07)

Approved for use through 06/30/2010. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MLHUM.002C1
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086108	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086063	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086057	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/091732	2008-08-25
Prior Application Status	Pending	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	12/497528	2009-07-02
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086060	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086108	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086063	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086057	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/078228	2008-07-03
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/078207	2008-07-03
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/091732	2008-08-25
Prior Application Status	Pending	<a href="#">Remove</a>	

CX-1622

PTO/SB/14 (07-07)

Approved for use through 06/30/2010. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MLHUM.002C1		
		Application Number			
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS				

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
12/497528	Continuation in part of	29/323409	2008-08-25
Prior Application Status	Patented	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
12/497528	Continuation in part of	29/323408	2008-08-25
Prior Application Status	Pending	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	12/497523	2009-07-02
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086060	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086108	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086063	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/086057	2008-08-04
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/078228	2008-07-03
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/078207	2008-07-03
Prior Application Status	Expired	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/091732	2008-08-25
Prior Application Status	Pending	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
12/497523	Continuation in part of	29/323409	2008-08-25
Prior Application Status	Patented	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
12/497523	Continuation in part of	29/323408	2008-08-25
Prior Application Status	Pending	<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
12/497523	Continuation in part of	29/323408	2008-08-25
Prior Application Status	Pending	<a href="#">Remove</a>	

PTO/SB/14 (07-07)

Approved for use through 06/30/2010. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MLHUM.002C1
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

**Foreign Priority Information:**

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

<a href="#">Remove</a>			
Application Number	Country	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			<input type="radio"/> Yes <input checked="" type="radio"/> No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

**Assignee Information:**

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

**Assignee 1**

If the Assignee is an Organization check here. ☐

Prefix	Given Name	Middle Name	Family Name	Suffix

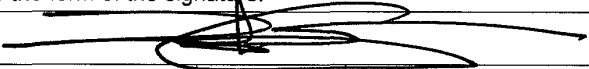
**Mailing Address Information:**

Address 1			
Address 2			
City		State/Province	
Country		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the **Add** button.

**Signature:**

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature			Date (YYYY-MM-DD)	2010-07-01	
First Name	John	Last Name	Grover	Registration Number	42610

CX-1622

PTO/SB/14 (07-07)

Approved for use through 06/30/2010. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MLHUM.002C1
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

## Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

MLHUM.002C1

PATENT

**MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE  
MEASUREMENT OF BLOOD CONSTITUENTS**

**RELATED APPLICATIONS**

**[0001]** This application is a continuation of U.S. Patent Application No. 12/534,827 filed August 3, 2009, which claims the benefit of priority under 35 U.S.C. § 119(e) of the following U.S. Provisional Patent Application Nos. 61/086,060 filed August 4, 2008, 61/086,108 filed August 4, 2008, 61/086,063 filed August 4, 2008, 61/086,057 filed August 4, 2008, and 61/091,732 filed August 25, 2008. This application is also a continuation of U.S. Patent Application No. 12/497,528 filed July 2, 2009, which claims the benefit of priority under 35 U.S.C. § 119(e) of the following U.S. Provisional Patent Application Nos. 61/086,060 filed August 4, 2008, 61/086,108 filed August 4, 2008, 61/086,063 filed August 4, 2008, 61/086,057 filed August 4, 2008, 61/078,228 filed July 3, 2008, 61/078,207 filed July 3, 2008, and 61/091,732 filed August 25, 2008. The '528 Application also claims the benefit of priority under 35 U.S.C. § 120 as a continuation-in-part of the following U.S. Design Patent Application Nos. 29/323,409 filed August 25, 2008 and 29/323,408 filed August 25, 2008. This application is also a continuation of U.S. Patent Application No. 12/497,523 filed July 2, 2009, which claims the benefit of priority under 35 U.S.C. § 119(e) of the following U.S. Provisional Patent Application Nos. 61/086,060 filed August 4, 2008, 61/086,108 filed August 4, 2008, 61/086,063 filed August 4, 2008, 61/086,057 filed August 4, 2008, 61/078,228 filed July 3, 2008, 61/078,207 filed July 3, 2008, and 61/091,732 filed August 25, 2008. The '523 Application also claims the benefit of priority under 35 U.S.C. § 120 as a continuation-in-part of the following U.S. Design Patent Application Nos. 29/323,409 filed August 25, 2008 and 29/323,408 filed August 25, 2008.

**[0002]** This application is related to the following U.S. Patent Applications:

<u>App. No.</u>	<u>Filing Date</u>	<u>Title</u>	<u>Attorney Docket</u>
12/497,528	7/2/09	Noise Shielding for Noninvasive Device	MLHUM.006A

12/497,523	7/2/09	<i>Contoured Protrusion for Improving Spectroscopic Measurement of Blood Constituents</i>	MLHUM.007A
12/498,506	7/2/09	<i>Heat Sink for Noninvasive Medical Sensor</i>	MLHUM.011A
Unknown	Herewith	<i>Multi-Stream Sensor Front Ends for Non-Invasive Measurement of Blood Constituents</i>	MLHUM.003A
Unknown	Herewith	<i>Multi-Stream Sensor for Non-Invasive Measurement of Blood Constituents</i>	MLHUM.004A
Unknown	Herewith	<i>Multi-Stream Emitter for Non-Invasive Measurement of Blood Constituents</i>	MLHUM.005A

**[0003]** The foregoing applications are hereby incorporated by reference in their entirety.

#### BACKGROUND

**[0004]** The standard of care in caregiver environments includes patient monitoring through spectroscopic analysis using, for example, a pulse oximeter. Devices capable of spectroscopic analysis generally include a light source(s) transmitting optical radiation into or reflecting off a measurement site, such as, body tissue carrying pulsing blood. After attenuation by tissue and fluids of the measurement site, a photodetection device(s) detects the attenuated light and outputs a detector signal(s) responsive to the detected attenuated light. A signal processing device(s) process the detector(s) signal(s) and outputs a measurement indicative of a blood constituent of interest, such as glucose, oxygen, met hemoglobin, total hemoglobin, other physiological parameters, or other data or combinations of data useful in determining a state or trend of wellness of a patient.

**[0005]** In noninvasive devices and methods, a sensor is often adapted to position a finger proximate the light source and light detector. For example, noninvasive sensors often include a clothespin-shaped housing that includes a contoured bed conforming generally to the shape of a finger.



### SUMMARY

**[0006]** This disclosure describes embodiments of noninvasive methods, devices, and systems for measuring a blood constituent or analyte, such as oxygen, carbon monoxide, methemoglobin, total hemoglobin, glucose, proteins, glucose, lipids, a percentage thereof (e.g., saturation) or for measuring many other physiologically relevant patient characteristics. These characteristics can relate, for example, to pulse rate, hydration, trending information and analysis, and the like.

**[0007]** In an embodiment, the system includes a noninvasive sensor and a patient monitor communicating with the noninvasive sensor. The non-invasive sensor may include different architectures to implement some or all of the disclosed features. In addition, an artisan will recognize that the non-invasive sensor may include or may be coupled to other components, such as a network interface, and the like. Moreover, the patient monitor may include a display device, a network interface communicating with any one or combination of a computer network, a handheld computing device, a mobile phone, the Internet, or the like. In addition, embodiments may include multiple optical sources that emit light at a plurality of wavelengths and that are arranged from the perspective of the light detector(s) as a point source.

**[0008]** In an embodiment, a noninvasive device is capable of producing a signal responsive to light attenuated by tissue at a measurement site. The device may comprise an optical source and a plurality of photodetectors. The optical source is configured to emit optical radiation at least at wavelengths between about 1600 nm and about 1700 nm. The photodetectors are configured to detect the optical radiation from said optical source after attenuation by the tissue of the measurement site and each output a respective signal stream responsive to the detected optical radiation.

**[0009]** In an embodiment, a noninvasive, physiological sensor is capable of outputting a signal responsive to a blood analyte present in a monitored patient. The sensor may comprise a sensor housing, an optical source, and photodetectors. The optical source is positioned by the housing with respect to a tissue site of a patient when said housing is applied to the patient. The photodetectors are

positioned by the housing with respect to said tissue site when the housing is applied to the patient with a variation in path length among at least some of the photodetectors from the optical source. The photodetectors are configured to detect a sequence of optical radiation from the optical source after attenuation by tissue of the tissue site. The photodetectors may be each configured to output a respective signal stream responsive to the detected sequence of optical radiation. An output signal responsive to one or more of the signal streams is then usable to determine the blood analyte based at least in part on the variation in path length

**[0010]** In an embodiment, a method of measuring an analyte based on multiple streams of optical radiation measured from a measurement site is provided. A sequence of optical radiation pulses is emitted to the measurement site. At a first location, a first stream of optical radiation is detected from the measurement site. At least at one additional location different from the first location, an additional stream of optical radiation is detected from the measurement site. An output measurement value indicative of the analyte is then determined based on the detected streams of optical radiation.

**[0011]** For purposes of summarizing the disclosure, certain aspects, advantages and novel features of the inventions have been described herein. It is to be understood that not necessarily all such advantages can be achieved in accordance with any particular embodiment of the inventions disclosed herein. Thus, the inventions disclosed herein can be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other advantages as can be taught or suggested herein.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0012]** Throughout the drawings, reference numbers can be re-used to indicate correspondence between referenced elements. The drawings are provided to illustrate embodiments of the inventions described herein and not to limit the scope thereof.

**[0013]** FIGURE 1 illustrates a block diagram of an example data collection system capable of noninvasively measuring one or more blood analytes in a monitored patient, according to an embodiment of the disclosure;

**[0014]** FIGURES 2A – 2D illustrate an exemplary handheld monitor and an exemplary noninvasive optical sensor of the patient monitoring system of Figure 1, according to embodiments of the disclosure;

**[0015]** FIGURES 3A – 3C illustrate side and perspective views of an exemplary noninvasive sensor housing including a finger bed protrusion and heat sink, according to an embodiment of the disclosure;

**[0016]** FIGURE 3D illustrates a side view of another example noninvasive sensor housing including a heat sink, according to an embodiment of the disclosure;

**[0017]** FIGURE 3E illustrates a perspective view of an example noninvasive sensor detector shell including example detectors, according to an embodiment of the disclosure;

**[0018]** FIGURE 3F illustrates a side view of an example noninvasive sensor housing including a finger bed protrusion and heat sink, according to an embodiment of the disclosure;

**[0019]** FIGURES 4A through 4C illustrate top elevation, side and top perspective views of an example protrusion, according to an embodiment of the disclosure;

**[0020]** FIGURE 5 illustrates an example graph depicting possible effects of a protrusion on light transmittance, according to an embodiment of the disclosure;

**[0021]** FIGURES 6A through 6D illustrate perspective, front elevation, side and top views of another example protrusion, according to an embodiment of the disclosure;

**[0022]** FIGURE 6E illustrates an example sensor incorporating the protrusion of FIGURES 6A through 6D, according to an embodiment of the disclosure;

**[0023]** FIGURES 7A through 7B illustrate example arrangements of conductive glass that may be employed in the system of FIGURE 1, according to embodiments of the disclosure.

**[0024]** FIGURES 8A through 8D illustrate an example top elevation view, side views, and a bottom elevation view of the conductive glass that may be employed in the system of FIGURE 1, according to embodiments of the disclosure;

**[0025]** FIGURE 9 shows example comparative results obtained by an embodiment of a sensor;

**[0026]** FIGURES 10A and 10B illustrate comparative noise floors of various embodiments of the present disclosure;

**[0027]** FIGURE 11A illustrates an exemplary emitter that may be employed in the sensor, according to an embodiment of the disclosure;

**[0028]** FIGURE 11B illustrates a configuration of emitting optical radiation into a measurement site for measuring blood constituents, according to an embodiment of the disclosure;

**[0029]** FIGURE 11C illustrates another exemplary emitter that may be employed in the sensor according to an embodiment of the disclosure;

**[0030]** FIGURE 11D illustrates another exemplary emitter that may be employed in the sensor according to an embodiment of the disclosure.

**[0031]** FIGURE 12A illustrates an example detector portion that may be employed in an embodiment of a sensor, according to an embodiment of the disclosure;

**[0032]** FIGURES 12B through 12D illustrate exemplary arrangements of detectors that may be employed in an embodiment of the sensor, according to some embodiments of the disclosure;

**[0033]** FIGURES 12E through 12H illustrate exemplary structures of photodiodes that may be employed in embodiments of the detectors, according to some embodiments of the disclosure;

**[0034]** FIGURE 13 illustrates an example multi-stream operation of the system of FIGURE 1, according to an embodiment of the disclosure;

**[0035]** FIGURE 14A illustrates another example detector portion having a partially cylindrical protrusion that can be employed in an embodiment of a sensor, according to an embodiment of the disclosure;

**[0036]** FIGURE 14B depicts a front elevation view of the partially cylindrical protrusion of FIGURE 14A;

**[0037]** FIGURES 14C through 14E illustrate embodiments of a detector submount;

**[0038]** FIGURES 14F through 14H illustrate embodiment of portions of a detector shell;

**[0039]** FIGURE 14I illustrates a cutaway view of an embodiment of a sensor;

**[0040]** FIGURES 15A through 15F illustrate embodiments of sensors that include heat sink features;

**[0041]** FIGURES 15G and 15H illustrate embodiments of connector features that can be used with any of the sensors described herein;

**[0042]** FIGURE 15I illustrates an exemplary architecture for a transimpedance-based front-end that may be employed in any of the sensors described herein;

**[0043]** FIGURE 15J illustrates an exemplary noise model for configuring the transimpedance-based front-ends shown in FIGURE 15I;

**[0044]** FIGURE 15K shows different architectures and layouts for various embodiments of a sensor and its detectors;

**[0045]** FIGURE 15L illustrates an exemplary architecture for a switched-capacitor-based front-end that may be employed in any of the sensors described herein;

**[0046]** FIGURES 16A and 16B illustrate embodiments of disposable optical sensors;

**[0047]** FIGURE 17 illustrates an exploded view of certain components of an example sensor; and

**[0048]** FIGURES 18 through 22 illustrate various results obtained by an exemplary sensor of the disclosure.

## DETAILED DESCRIPTION

**[0049]** The present disclosure generally relates to non-invasive medical devices. In the present disclosure, a sensor can measure various blood constituents or analytes noninvasively using multi-stream spectroscopy. In an embodiment, the multi-stream spectroscopy can employ visible, infrared and near infrared wavelengths. As disclosed herein, the sensor is capable of noninvasively measuring blood analytes or percentages thereof (e.g., saturation) based on various combinations of features and components.

**[0050]** The sensor can include photocommunicative components, such as an emitter, a detector, and other components. The emitter can include a plurality of sets of optical sources that, in an embodiment, are arranged together as a point source. The various optical sources can emit a sequence of optical radiation pulses at different wavelengths towards a measurement site, such as a patient's finger. Detectors can then detect optical radiation from the measurement site. The optical sources and optical radiation detectors can operate at any appropriate wavelength, including, as discussed herein, infrared, near infrared, visible light, and ultraviolet. In addition, the optical sources and optical radiation detectors can operate at any appropriate wavelength, and such modifications to the embodiments desirable to operate at any such wavelength will be apparent to those skilled in the art.

**[0051]** In certain embodiments, multiple detectors are employed and arranged in a spatial geometry. This spatial geometry provides a diversity of path lengths among at least some of the detectors and allows for multiple bulk and pulsatile measurements that are robust. Each of the detectors can provide a respective output stream based on the detected optical radiation, or a sum of output streams can be provided from multiple detectors. In some embodiments, the sensor can also include other components, such as one or more heat sinks and one or more thermistors.

**[0052]** The sensor can be coupled to one or more monitors that process and/or display the sensor's output. The monitors can include various components, such as a sensor front end, a signal processor, a display, etc.

**[0053]** The sensor can be integrated with a monitor, for example, into a handheld unit including the sensor, a display and user controls. In other embodiments, the sensor can communicate with one or more processing devices. The communication can be via wire(s), cable(s), flex circuit(s), wireless technologies, or other suitable analog or digital communication methodologies and devices to perform those methodologies. Many of the foregoing arrangements allow the sensor to be attached to the measurement site while the device is attached elsewhere on a patient, such as the patient's arm, or placed at a location near the patient, such as a bed, shelf or table. The sensor or monitor can also provide outputs to a storage device or network interface.

**[0054]** Reference will now be made to the Figures to discuss embodiments of the present disclosure.

**[0055]** **FIGURE 1** illustrates an example of a data collection system 100. In certain embodiments, the data collection system 100 noninvasively measure a blood analyte, such as oxygen, carbon monoxide, methemoglobin, total hemoglobin, glucose, proteins, lipids, a percentage thereof (e.g., saturation) or for measuring many other physiologically relevant patient characteristics. The system 100 can also measure additional blood analytes and/or other physiological parameters useful in determining a state or trend of wellness of a patient.

**[0056]** The data collection system 100 can be capable of measuring optical radiation from the measurement site. For example, in some embodiments, the data collection system 100 can employ photodiodes defined in terms of area. In an embodiment, the area is from about  $1 \text{ mm}^2$  –  $5 \text{ mm}^2$  (or higher) that are capable of detecting about 100 nanoamps (nA) or less of current resulting from measured light at full scale. In addition to having its ordinary meaning, the phrase “at full scale” can mean light saturation of a photodiode amplifier (not shown). Of course, as would be understood by a person of skill in the art from the present disclosure, various other sizes and types of photodiodes can be used with the embodiments of the present disclosure.

**[0057]** The data collection system 100 can measure a range of approximately about 2 nA to about 100 nA full scale. The data collection system



100 can also include sensor front-ends that are capable of processing and amplifying current from the detector(s) at signal-to-noise ratios (SNRs) of about 100 decibels (dB) or more, such as about 120 dB in order to measure various desired analytes. The data collection system 100 can operate with a lower SNR if less accuracy is desired for an analyte like glucose.

**[0058]** The data collection system 100 can measure analyte concentrations, including glucose, at least in part by detecting light attenuated by a measurement site 102. The measurement site 102 can be any location on a patient's body, such as a finger, foot, ear lobe, or the like. For convenience, this disclosure is described primarily in the context of a finger measurement site 102. However, the features of the embodiments disclosed herein can be used with other measurement sites 102.

**[0059]** In the depicted embodiment, the system 100 includes an optional tissue thickness adjuster or tissue shaper 105, which can include one or more protrusions, bumps, lenses, or other suitable tissue-shaping mechanisms. In certain embodiments, the tissue shaper 105 is a flat or substantially flat surface that can be positioned proximate the measurement site 102 and that can apply sufficient pressure to cause the tissue of the measurement site 102 to be flat or substantially flat. In other embodiments, the tissue shaper 105 is a convex or substantially convex surface with respect to the measurement site 102. Many other configurations of the tissue shaper 105 are possible. Advantageously, in certain embodiments, the tissue shaper 105 reduces thickness of the measurement site 102 while preventing or reducing occlusion at the measurement site 102. Reducing thickness of the site can advantageously reduce the amount of attenuation of the light because there is less tissue through which the light must travel. Shaping the tissue in to a convex (or alternatively concave) surface can also provide more surface area from which light can be detected.

**[0060]** The embodiment of the data collection system 100 shown also includes an optional noise shield 103. In an embodiment, the noise shield 103 can be advantageously adapted to reduce electromagnetic noise while increasing the transmittance of light from the measurement site 102 to one or more detectors 106

(described below). For example, the noise shield 103 can advantageously include a conductive coated glass or metal grid electrically communicating with one or more other shields of the sensor 101 or electrically grounded. In an embodiment where the noise shield 103 includes conductive coated glass, the coating can advantageously include indium tin oxide. In an embodiment, the indium tin oxide includes a surface resistivity ranging from approximately 30 ohms per square inch to about 500 ohms per square inch. In an embodiment, the resistivity is approximately 30, 200, or 500 ohms per square inch. As would be understood by a person of skill in the art from the present disclosure, other resistivities can also be used which are less than about 30 ohms or more than about 500 ohms. Other conductive materials transparent or substantially transparent to light can be used instead.

**[0061]** In some embodiments, the measurement site 102 is located somewhere along a non-dominant arm or a non-dominant hand, e.g., a right-handed person's left arm or left hand. In some patients, the non-dominant arm or hand can have less musculature and higher fat content, which can result in less water content in that tissue of the patient. Tissue having less water content can provide less interference with the particular wavelengths that are absorbed in a useful manner by blood analytes like glucose. Accordingly, in some embodiments, the data collection system 100 can be used on a person's non-dominant hand or arm.

**[0062]** The data collection system 100 can include a sensor 101 (or multiple sensors) that is coupled to a processing device or physiological monitor 109. In an embodiment, the sensor 101 and the monitor 109 are integrated together into a single unit. In another embodiment, the sensor 101 and the monitor 109 are separate from each other and communicate one with another in any suitable manner, such as via a wired or wireless connection. The sensor 101 and monitor 109 can be attachable and detachable from each other for the convenience of the user or caregiver, for ease of storage, sterility issues, or the like. The sensor 101 and the monitor 109 will now be further described.

**[0063]** In the depicted embodiment shown in **FIGURE 1**, the sensor 101 includes an emitter 104, a tissue shaper 105, a set of detectors 106, and a front-end interface 108. The emitter 104 can serve as the source of optical radiation

transmitted towards measurement site 102. As will be described in further detail below, the emitter 104 can include one or more sources of optical radiation, such as LEDs, laser diodes, incandescent bulbs with appropriate frequency-selective filters, combinations of the same, or the like. In an embodiment, the emitter 104 includes sets of optical sources that are capable of emitting visible and near-infrared optical radiation.

**[0064]** In some embodiments, the emitter 104 is used as a point optical source, and thus, the one or more optical sources of the emitter 104 can be located within a close distance to each other, such as within about a 2 mm to about 4 mm. The emitters 104 can be arranged in an array, such as is described in U.S. Publication No. 2006/0211924, filed Sept. 21, 2006, titled "Multiple Wavelength Sensor Emitters," the disclosure of which is hereby incorporated by reference in its entirety. In particular, the emitters 104 can be arranged at least in part as described in paragraphs [0061] through [0068] of the aforementioned publication, which paragraphs are hereby incorporated specifically by reference. Other relative spatial relationships can be used to arrange the emitters 104.

**[0065]** For analytes like glucose, currently available non-invasive techniques often attempt to employ light near the water absorbance minima at or about 1600 nm. Typically, these devices and methods employ a single wavelength or single band of wavelengths at or about 1600 nm. However, to date, these techniques have been unable to adequately consistently measure analytes like glucose based on spectroscopy.

**[0066]** In contrast, the emitter 104 of the data collection system 100 can emit, in certain embodiments, combinations of optical radiation in various bands of interest. For example, in some embodiments, for analytes like glucose, the emitter 104 can emit optical radiation at three (3) or more wavelengths between about 1600 nm to about 1700 nm. In particular, the emitter 104 can emit optical radiation at or about 1610 nm, about 1640 nm, and about 1665 nm. In some circumstances, the use of three wavelengths within about 1600 nm to about 1700 nm enable sufficient SNRs of about 100 dB, which can result in a measurement accuracy of about 20 mg/dL or better for analytes like glucose.

**[0067]** In other embodiments, the emitter 104 can use two (2) wavelengths within about 1600 nm to about 1700 nm to advantageously enable SNRs of about 85 dB, which can result in a measurement accuracy of about 25-30 mg/dL or better for analytes like glucose. Furthermore, in some embodiments, the emitter 104 can emit light at wavelengths above about 1670 nm. Measurements at these wavelengths can be advantageously used to compensate or confirm the contribution of protein, water, and other non-hemoglobin species exhibited in measurements for analytes like glucose conducted between about 1600 nm and about 1700 nm. Of course, other wavelengths and combinations of wavelengths can be used to measure analytes and/or to distinguish other types of tissue, fluids, tissue properties, fluid properties, combinations of the same or the like.

**[0068]** For example, the emitter 104 can emit optical radiation across other spectra for other analytes. In particular, the emitter 104 can employ light wavelengths to measure various blood analytes or percentages (e.g., saturation) thereof. For example, in one embodiment, the emitter 104 can emit optical radiation in the form of pulses at wavelengths about 905 nm, about 1050 nm, about 1200 nm, about 1300 nm, about 1330 nm, about 1610 nm, about 1640 nm, and about 1665 nm. In another embodiment, the emitter 104 can emit optical radiation ranging from about 860 nm to about 950 nm, about 950 nm to about 1100 nm, about 1100 nm to about 1270 nm, about 1250 nm to about 1350 nm, about 1300 nm to about 1360 nm, and about 1590 nm to about 1700 nm. Of course, the emitter 104 can transmit any of a variety of wavelengths of visible or near-infrared optical radiation.

**[0069]** Due to the different responses of analytes to the different wavelengths, certain embodiments of the data collection system 100 can advantageously use the measurements at these different wavelengths to improve the accuracy of measurements. For example, the measurements of water from visible and infrared light can be used to compensate for water absorbance that is exhibited in the near-infrared wavelengths.

**[0070]** As briefly described above, the emitter 104 can include sets of light-emitting diodes (LEDs) as its optical source. The emitter 104 can use one or

more top-emitting LEDs. In particular, in some embodiments, the emitter 104 can include top-emitting LEDs emitting light at about 850 nm to 1350 nm.

**[0071]** The emitter 104 can also use super luminescent LEDs (SLEDs) or side-emitting LEDs. In some embodiments, the emitter 104 can employ SLEDs or side-emitting LEDs to emit optical radiation at about 1600 nm to about 1800 nm. Emitter 104 can use SLEDs or side-emitting LEDs to transmit near infrared optical radiation because these types of sources can transmit at high power or relatively high power, e.g., about 40 mW to about 100 mW. This higher power capability can be useful to compensate or overcome the greater attenuation of these wavelengths of light in tissue and water. For example, the higher power emission can effectively compensate and/or normalize the absorption signal for light in the mentioned wavelengths to be similar in amplitude and/or effect as other wavelengths that can be detected by one or more photodetectors after absorption. However, the embodiments of the present disclosure do not necessarily require the use of high power optical sources. For example, some embodiments may be configured to measure analytes, such as total hemoglobin (tHb), oxygen saturation (SpO<sub>2</sub>), carboxyhemoglobin, methemoglobin, etc., without the use of high power optical sources like side emitting LEDs. Instead, such embodiments may employ other types of optical sources, such as top emitting LEDs. Alternatively, the emitter 104 can use other types of sources of optical radiation, such as a laser diode, to emit near-infrared light into the measurement site 102.

**[0072]** In addition, in some embodiments, in order to assist in achieving a comparative balance of desired power output between the LEDs, some of the LEDs in the emitter 104 can have a filter or covering that reduces and/or cleans the optical radiation from particular LEDs or groups of LEDs. For example, since some wavelengths of light can penetrate through tissue relatively well, LEDs, such as some or all of the top-emitting LEDs can use a filter or covering, such as a cap or painted dye. This can be useful in allowing the emitter 104 to use LEDs with a higher output and/or to equalize intensity of LEDs.

**[0073]** The data collection system 100 also includes a driver 111 that drives the emitter 104. The driver 111 can be a circuit or the like that is controlled

by the monitor 109. For example, the driver 111 can provide pulses of current to the emitter 104. In an embodiment, the driver 111 drives the emitter 104 in a progressive fashion, such as in an alternating manner. The driver 111 can drive the emitter 104 with a series of pulses of about 1 milliwatt (mW) for some wavelengths that can penetrate tissue relatively well and from about 40 mW to about 100 mW for other wavelengths that tend to be significantly absorbed in tissue. A wide variety of other driving powers and driving methodologies can be used in various embodiments.

**[0074]** The driver 111 can be synchronized with other parts of the sensor 101 and can minimize or reduce jitter in the timing of pulses of optical radiation emitted from the emitter 104. In some embodiments, the driver 111 is capable of driving the emitter 104 to emit optical radiation in a pattern that varies by less than about 10 parts-per-million.

**[0075]** The detectors 106 capture and measure light from the measurement site 102. For example, the detectors 106 can capture and measure light transmitted from the emitter 104 that has been attenuated or reflected from the tissue in the measurement site 102. The detectors 106 can output a detector signal 107 responsive to the light captured or measured. The detectors 106 can be implemented using one or more photodiodes, phototransistors, or the like.

**[0076]** In addition, the detectors 106 can be arranged with a spatial configuration to provide a variation of path lengths among at least some of the detectors 106. That is, some of the detectors 106 can have the substantially, or from the perspective of the processing algorithm, effectively, the same path length from the emitter 104. However, according to an embodiment, at least some of the detectors 106 can have a different path length from the emitter 104 relative to other of the detectors 106. Variations in path lengths can be helpful in allowing the use of a bulk signal stream from the detectors 106. In some embodiments, the detectors 106 may employ a linear spacing, a logarithmic spacing, or a two or three dimensional matrix of spacing, or any other spacing scheme in order to provide an appropriate variation in path lengths.

**[0077]** The front end interface 108 provides an interface that adapts the output of the detectors 106, which is responsive to desired physiological parameters. For example, the front end interface 108 can adapt a signal 107 received from one or more of the detectors 106 into a form that can be processed by the monitor 109, for example, by a signal processor 110 in the monitor 109. The front end interface 108 can have its components assembled in the sensor 101, in the monitor 109, in connecting cabling (if used), combinations of the same, or the like. The location of the front end interface 108 can be chosen based on various factors including space desired for components, desired noise reductions or limits, desired heat reductions or limits, and the like.

**[0078]** The front end interface 108 can be coupled to the detectors 106 and to the signal processor 110 using a bus, wire, electrical or optical cable, flex circuit, or some other form of signal connection. The front end interface 108 can also be at least partially integrated with various components, such as the detectors 106. For example, the front end interface 108 can include one or more integrated circuits that are on the same circuit board as the detectors 106. Other configurations can also be used.

**[0079]** The front end interface 108 can be implemented using one or more amplifiers, such as transimpedance amplifiers, that are coupled to one or more analog to digital converters (ADCs) (which can be in the monitor 109), such as a sigma-delta ADC. A transimpedance-based front end interface 108 can employ single-ended circuitry, differential circuitry, and/or a hybrid configuration. A transimpedance-based front end interface 108 can be useful for its sampling rate capability and freedom in modulation/demodulation algorithms. For example, this type of front end interface 108 can advantageously facilitate the sampling of the ADCs being synchronized with the pulses emitted from the emitter 104.

**[0080]** The ADC or ADCs can provide one or more outputs into multiple channels of digital information for processing by the signal processor 110 of the monitor 109. Each channel can correspond to a signal output from a detector 106.

**[0081]** In some embodiments, a programmable gain amplifier (PGA) can be used in combination with a transimpedance-based front end interface 108. For

example, the output of a transimpedance-based front end interface 108 can be output to a PGA that is coupled with an ADC in the monitor 109. A PGA can be useful in order to provide another level of amplification and control of the stream of signals from the detectors 106. Alternatively, the PGA and ADC components can be integrated with the transimpedance-based front end interface 108 in the sensor 101.

**[0082]** In another embodiment, the front end interface 108 can be implemented using switched-capacitor circuits. A switched-capacitor-based front end interface 108 can be useful for, in certain embodiments, its resistor-free design and analog averaging properties. In addition, a switched-capacitor-based front end interface 108 can be useful because it can provide a digital signal to the signal processor 110 in the monitor 109.

**[0083]** As shown in **FIGURE 1**, the monitor 109 can include the signal processor 110 and a user interface, such as a display 112. The monitor 109 can also include optional outputs alone or in combination with the display 112, such as a storage device 114 and a network interface 116. In an embodiment, the signal processor 110 includes processing logic that determines measurements for desired analytes, such as glucose, based on the signals received from the detectors 106. The signal processor 110 can be implemented using one or more microprocessors or subprocessors (e.g., cores), digital signal processors, application specific integrated circuits (ASICs), field programmable gate arrays (FPGAs), combinations of the same, and the like.

**[0084]** The signal processor 110 can provide various signals that control the operation of the sensor 101. For example, the signal processor 110 can provide an emitter control signal to the driver 111. This control signal can be useful in order to synchronize, minimize, or reduce jitter in the timing of pulses emitted from the emitter 104. Accordingly, this control signal can be useful in order to cause optical radiation pulses emitted from the emitter 104 to follow a precise timing and consistent pattern. For example, when a transimpedance-based front end interface 108 is used, the control signal from the signal processor 110 can provide synchronization with the ADC in order to avoid aliasing, cross-talk, and the like. As



also shown, an optional memory 113 can be included in the front-end interface 108 and/or in the signal processor 110. This memory 113 can serve as a buffer or storage location for the front-end interface 108 and/or the signal processor 110, among other uses.

**[0085]** The user interface 112 can provide an output, e.g., on a display, for presentation to a user of the data collection system 100. The user interface 112 can be implemented as a touch-screen display, an LCD display, an organic LED display, or the like. In addition, the user interface 112 can be manipulated to allow for measurement on the non-dominant side of patient. For example, the user interface 112 can include a flip screen, a screen that can be moved from one side to another on the monitor 109, or can include an ability to reorient its display indicia responsive to user input or device orientation. In alternative embodiments, the data collection system 100 can be provided without a user interface 112 and can simply provide an output signal to a separate display or system.

**[0086]** A storage device 114 and a network interface 116 represent other optional output connections that can be included in the monitor 109. The storage device 114 can include any computer-readable medium, such as a memory device, hard disk storage, EEPROM, flash drive, or the like. The various software and/or firmware applications can be stored in the storage device 114, which can be executed by the signal processor 110 or another processor of the monitor 109. The network interface 116 can be a serial bus port (RS-232/RS-485), a Universal Serial Bus (USB) port, an Ethernet port, a wireless interface (e.g., WiFi such as any 802.1x interface, including an internal wireless card), or other suitable communication device(s) that allows the monitor 109 to communicate and share data with other devices. The monitor 109 can also include various other components not shown, such as a microprocessor, graphics processor, or controller to output the user interface 112, to control data communications, to compute data trending, or to perform other operations.

**[0087]** Although not shown in the depicted embodiment, the data collection system 100 can include various other components or can be configured in different ways. For example, the sensor 101 can have both the emitter 104 and

detectors 106 on the same side of the measurement site 102 and use reflectance to measure analytes. The data collection system 100 can also include a sensor that measures the power of light emitted from the emitter 104.

**[0088]** FIGURES 2A through 2D illustrate example monitoring devices 200 in which the data collection system 100 can be housed. Advantageously, in certain embodiments, some or all of the example monitoring devices 200 shown can have a shape and size that allows a user to operate it with a single hand or attach it, for example, to a patient's body or limb. Although several examples are shown, many other monitoring device configurations can be used to house the data collection system 100. In addition, certain of the features of the monitoring devices 200 shown in FIGURES 2A through 2D can be combined with features of the other monitoring devices 200 shown.

**[0089]** Referring specifically to **FIGURE 2A**, an example monitoring device 200A is shown, in which a sensor 201a and a monitor 209a are integrated into a single unit. The monitoring device 200A shown is a handheld or portable device that can measure glucose and other analytes in a patient's finger. The sensor 201a includes an emitter shell 204a and a detector shell 206a. The depicted embodiment of the monitoring device 200A also includes various control buttons 208a and a display 210a.

**[0090]** The sensor 201a can be constructed of white material used for reflective purposes (such as white silicone or plastic), which can increase the usable signal at the detector 106 by forcing light back into the sensor 201a. Pads in the emitter shell 204a and the detector shell 206a can contain separated windows to prevent or reduce mixing of light signals, for example, from distinct quadrants on a patient's finger. In addition, these pads can be made of a relatively soft material, such as a gel or foam, in order to conform to the shape, for example, of a patient's finger. The emitter shell 204a and the detector shell 206a can also include absorbing black or grey material portions to prevent or reduce ambient light from entering into the sensor 201a.

**[0091]** In some embodiments, some or all portions of the emitter shell 204a and/or detector shell 206a can be detachable and/or disposable. For

example, some or all portions of the shells 204a and 206a can be removable pieces. The removability of the shells 204a and 206a can be useful for sanitary purposes or for sizing the sensor 201a to different patients. The monitor 209a can include a fitting, slot, magnet, or other connecting mechanism to allow the sensor 201c to be removably attached to the monitor 209a.

**[0092]** The monitoring device 200a also includes optional control buttons 208a and a display 210a that can allow the user to control the operation of the device. For example, a user can operate the control buttons 208a to view one or more measurements of various analytes, such as glucose. In addition, the user can operate the control buttons 208a to view other forms of information, such as graphs, histograms, measurement data, trend measurement data, parameter combination views, wellness indications, and the like. Many parameters, trends, alarms and parameter displays could be output to the display 210a, such as those that are commercially available through a wide variety of noninvasive monitoring devices from Masimo<sup>®</sup> Corporation of Irvine, California.

**[0093]** Furthermore, the controls 208a and/or display 210a can provide functionality for the user to manipulate settings of the monitoring device 200a, such as alarm settings, emitter settings, detector settings, and the like. The monitoring device 200a can employ any of a variety of user interface designs, such as frames, menus, touch-screens, and any type of button.

**[0094]** **FIGURE 2B** illustrates another example of a monitoring device 200B. In the depicted embodiment, the monitoring device 200B includes a finger clip sensor 201b connected to a monitor 209b via a cable 212. In the embodiment shown, the monitor 209b includes a display 210b, control buttons 208b and a power button. Moreover, the monitor 209b can advantageously include electronic processing, signal processing, and data storage devices capable of receiving signal data from said sensor 201b, processing the signal data to determine one or more output measurement values indicative of one or more physiological parameters of a monitored patient, and displaying the measurement values, trends of the measurement values, combinations of measurement values, and the like.

**[0095]** The cable 212 connecting the sensor 201b and the monitor 209b can be implemented using one or more wires, optical fiber, flex circuits, or the like. In some embodiments, the cable 212 can employ twisted pairs of conductors in order to minimize or reduce cross-talk of data transmitted from the sensor 201b to the monitor 209b. Various lengths of the cable 212 can be employed to allow for separation between the sensor 201b and the monitor 209b. The cable 212 can be fitted with a connector (male or female) on either end of the cable 212 so that the sensor 201b and the monitor 209b can be connected and disconnected from each other. Alternatively, the sensor 201b and the monitor 209b can be coupled together via a wireless communication link, such as an infrared link, radio frequency channel, or any other wireless communication protocol and channel.

**[0096]** The monitor 209b can be attached to the patient. For example, the monitor 209b can include a belt clip or straps (see, e.g., FIGURE 2C) that facilitate attachment to a patient's belt, arm, leg, or the like. The monitor 209b can also include a fitting, slot, magnet, LEMO snap-click connector, or other connecting mechanism to allow the cable 212 and sensor 201b to be attached to the monitor 209B.

**[0097]** The monitor 209b can also include other components, such as a speaker, power button, removable storage or memory (e.g., a flash card slot), an AC power port, and one or more network interfaces, such as a universal serial bus interface or an Ethernet port. For example, the monitor 209b can include a display 210b that can indicate a measurement for glucose, for example, in mg/dL. Other analytes and forms of display can also appear on the monitor 209b.

**[0098]** In addition, although a single sensor 201b with a single monitor 209b is shown, different combinations of sensors and device pairings can be implemented. For example, multiple sensors can be provided for a plurality of differing patient types or measurement sites or even patient fingers.

**[0099]** **FIGURE 2C** illustrates yet another example of monitoring device 200C that can house the data collection system 100. Like the monitoring device 200B, the monitoring device 200C includes a finger clip sensor 201c connected to a monitor 209c via a cable 212. The cable 212 can have all of the features described

above with respect to FIGURE 2B. The monitor 209c can include all of the features of the monitor 200B described above. For example, the monitor 209c includes buttons 208c and a display 210c. The monitor 209c shown also includes straps 214c that allow the monitor 209c to be attached to a patient's limb or the like.

**[0100]** FIGURE 2D illustrates yet another example of monitoring device 200D that can house the data collection system 100. Like the monitoring devices 200B and 200C, the monitoring device 200D includes a finger clip sensor 201d connected to a monitor 209d via a cable 212. The cable 212 can have all of the features described above with respect to FIGURE 2B. In addition to having some or all of the features described above with respect to FIGURES 2B and 2C, the monitoring device 200D includes an optional universal serial bus (USB) port 216 and an Ethernet port 218. The USB port 216 and the Ethernet port 218 can be used, for example, to transfer information between the monitor 209d and a computer (not shown) via a cable. Software stored on the computer can provide functionality for a user to, for example, view physiological data and trends, adjust settings and download firmware updates to the monitor 209b, and perform a variety of other functions. The USB port 216 and the Ethernet port 218 can be included with the other monitoring devices 200A, 200B, and 200C described above.

**[0101]** FIGURES 3A through 3C illustrate more detailed examples of embodiments of a sensor 301a. The sensor 301a shown can include all of the features of the sensors 100 and 200 described above.

**[0102]** Referring to FIGURE 3A, the sensor 301a in the depicted embodiment is a clothespin-shaped clip sensor that includes an enclosure 302a for receiving a patient's finger. The enclosure 302a is formed by an upper section or emitter shell 304a, which is pivotably connected with a lower section or detector shell 306a. The emitter shell 304a can be biased with the detector shell 306a to close together around a pivot point 303a and thereby sandwich finger tissue between the emitter and detector shells 304a, 306a.

**[0103]** In an embodiment, the pivot point 303a advantageously includes a pivot capable of adjusting the relationship between the emitter and detector shells 304a, 306a to effectively level the sections when applied to a tissue site. In another

embodiment, the sensor 301a includes some or all features of the finger clip described in U.S. Publication No. 2006/0211924, incorporated above, such as a spring that causes finger clip forces to be distributed along the finger. Paragraphs [0096] through [0105], which describe this feature, are hereby specifically incorporated by reference.

**[0104]** The emitter shell 304a can position and house various emitter components of the sensor 301a. It can be constructed of reflective material (e.g., white silicone or plastic) and/or can be metallic or include metalized plastic (e.g., including carbon and aluminum) to possibly serve as a heat sink. The emitter shell 304a can also include absorbing opaque material, such as, for example, black or grey colored material, at various areas, such as on one or more flaps 307a, to reduce ambient light entering the sensor 301a.

**[0105]** The detector shell 306a can position and house one or more detector portions of the sensor 301a. The detector shell 306a can be constructed of reflective material, such as white silicone or plastic. As noted, such materials can increase the usable signal at a detector by forcing light back into the tissue and measurement site (see FIGURE 1). The detector shell 306a can also include absorbing opaque material at various areas, such as lower area 308a, to reduce ambient light entering the sensor 301a.

**[0106]** Referring to **FIGURES 3B** and **3C**, an example of finger bed 310 is shown in the sensor 301b. The finger bed 310 includes a generally curved surface shaped generally to receive tissue, such as a human digit. The finger bed 310 includes one or more ridges or channels 314. Each of the ridges 314 has a generally convex shape that can facilitate increasing traction or gripping of the patient's finger to the finger bed. Advantageously, the ridges 314 can improve the accuracy of spectroscopic analysis in certain embodiments by reducing noise that can result from a measurement site moving or shaking loose inside of the sensor 301a. The ridges 314 can be made from reflective or opaque materials in some embodiments to further increase SNR. In other implementations, other surface shapes can be used, such as, for example, generally flat, concave, or convex finger beds 310.

**[0107]** Finger bed 310 can also include an embodiment of a tissue thickness adjuster or protrusion 305. The protrusion 305 includes a measurement site contact area 370 (see FIGURE 3C) that can contact body tissue of a measurement site. The protrusion 305 can be removed from or integrated with the finger bed 310. Interchangeable, different shaped protrusions 305 can also be provided, which can correspond to different finger shapes, characteristics, opacity, sizes, or the like.

**[0108]** Referring specifically to **FIGURE 3C**, the contact area 370 of the protrusion 305 can include openings or windows 320, 321, 322, and 323. When light from a measurement site passes through the windows 320, 321, 322, and 323, the light can reach one or more photodetectors (see FIGURE 3E). In an embodiment, the windows 320, 321, 322, and 323 mirror specific detector placements layouts such that light can impinge through the protrusion 305 onto the photodetectors. Any number of windows 320, 321, 322, and 323 can be employed in the protrusion 305 to allow light to pass from the measurement site to the photodetectors.

**[0109]** The windows 320, 321, 322, and 323 can also include shielding, such as an embedded grid of wiring or a conductive glass coating, to reduce noise from ambient light or other electromagnetic noise. The windows 320, 321, 322, and 323 can be made from materials, such as plastic or glass. In some embodiments, the windows 320, 321, 322, and 323 can be constructed from conductive glass, such as indium tin oxide (ITO) coated glass. Conductive glass can be useful because its shielding is transparent, and thus allows for a larger aperture versus a window with an embedded grid of wiring. In addition, in certain embodiments, the conductive glass does not need openings in its shielding (since it is transparent), which enhances its shielding performance. For example, some embodiments that employ the conductive glass can attain up to an about 40% to about 50% greater signal than non-conductive glass with a shielding grid. In addition, in some embodiments, conductive glass can be useful for shielding noise from a greater variety of directions than non-conductive glass with a shielding grid.

**[0110]** Turning to **FIGURE 3B**, the sensor 301a can also include a shielding 315a, such as a metal cage, box, metal sheet, perforated metal sheet, a metal layer on a non-metal material, or the like. The shielding 315a is provided in the depicted embodiment below or embedded within the protrusion 305 to reduce noise. The shielding 315a can be constructed from a conductive material, such as copper. The shielding 315a can include one or more openings or windows (not shown). The windows can be made from glass or plastic to thereby allow light that has passed through the windows 320, 321, 322, and 323 on an external surface of the protrusion 305 (see **FIGURE 3C**) to pass through to one or more photodetectors that can be enclosed or provided below (see **FIGURE 3E**).

**[0111]** In some embodiments, the shielding cage for shielding 315a can be constructed in a single manufactured component with or without the use of conductive glass. This form of construction may be useful in order to reduce costs of manufacture as well as assist in quality control of the components. Furthermore, the shielding cage can also be used to house various other components, such as sigma delta components for various embodiments of front end interfaces 108.

**[0112]** In an embodiment, the photodetectors can be positioned within or directly beneath the protrusion 305 (see **FIGURE 3E**). In such cases, the mean optical path length from the emitters to the detectors can be reduced and the accuracy of blood analyte measurement can increase. For example, in one embodiment, a convex bump of about 1 mm to about 3 mm in height and about 10 mm<sup>2</sup> to about 60 mm<sup>2</sup> was found to help signal strength by about an order of magnitude versus other shapes. Of course other dimensions and sizes can be employed in other embodiments. Depending on the properties desired, the length, width, and height of the protrusion 305 can be selected. In making such determinations, consideration can be made of protrusion's 305 effect on blood flow at the measurement site and mean path length for optical radiation passing through openings 320, 321, 322, and 323. Patient comfort can also be considered in determining the size and shape of the protrusion.

**[0113]** In an embodiment, the protrusion 305 can include a pliant material, including soft plastic or rubber, which can somewhat conform to the shape of a



measurement site. Pliant materials can improve patient comfort and tactility by conforming the measurement site contact area 370 to the measurement site. Additionally, pliant materials can minimize or reduce noise, such as ambient light. Alternatively, the protrusion 305 can be made from a rigid material, such as hard plastic or metal.

**[0114]** Rigid materials can improve measurement accuracy of a blood analyte by conforming the measurement site to the contact area 370. The contact area 370 can be an ideal shape for improving accuracy or reducing noise. Selecting a material for the protrusion 305 can include consideration of materials that do not significantly alter blood flow at the measurement site. The protrusion 305 and the contact area 370 can include a combination of materials with various characteristics.

**[0115]** The contact area 370 serves as a contact surface for the measurement site. For example, in some embodiments, the contact area 370 can be shaped for contact with a patient's finger. Accordingly, the contact area 370 can be sized and shaped for different sizes of fingers. The contact area 370 can be constructed of different materials for reflective purposes as well as for the comfort of the patient. For example, the contact area 370 can be constructed from materials having various hardness and textures, such as plastic, gel, foam, and the like.

**[0116]** The formulas and analysis that follow with respect to **FIGURE 5** provide insight into how selecting these variables can alter transmittance and intensity gain of optical radiation that has been applied to the measurement site. These examples do not limit the scope of this disclosure.

**[0117]** Referring to **FIGURE 5**, a plot 500 is shown that illustrates examples of effects of embodiments of the protrusion 305 on the SNR at various wavelengths of light. As described above, the protrusion 305 can assist in conforming the tissue and effectively reduce its mean path length. In some instances, this effect by the protrusion 305 can have significant impact on increasing the SNR.

**[0118]** According to the Beer Lambert law, a transmittance of light ( $I$ ) can be expressed as follows:  $I = I_0 * e^{-m*b*c}$ , where  $I_0$  is the initial power of light being transmitted,  $m$  is the path length traveled by the light, and the component " $b*c$ "

corresponds to the bulk absorption of the light at a specific wavelength of light. For light at about 1600 nm to about 1700 nm, for example, the bulk absorption component is generally around  $0.7 \text{ mm}^{-1}$ . Assuming a typical finger thickness of about 12 mm and a mean path length of 20 mm due to tissue scattering, then  $I = I_0 * e^{(-20*0.7)}$ .

**[0119]** In an embodiment where the protrusion 305 is a convex bump, the thickness of the finger can be reduced to 10 mm (from 12 mm) for some fingers and the effective light mean path is reduced to about 16.6 mm from 20 mm (see box 510). This results in a new transmittance,  $I_1 = I_0 * e^{(-16.6*0.7)}$ . A curve for a typical finger (having a mean path length of 20 mm) across various wavelengths is shown in the plot 500 of **FIGURE 5**. The plot 500 illustrates potential effects of the protrusion 305 on the transmittance. As illustrated, comparing  $I$  and  $I_1$  results in an intensity gain of  $e^{(-16.6*0.7)}/e^{(-20*0.7)}$ , which is about a 10 times increase for light in the about 1600 nm to about 1700 nm range. Such an increase can affect the SNR at which the sensor can operate. The foregoing gains can be due at least in part to the about 1600 nm to about 1700 nm range having high values in bulk absorptions (water, protein, and the like), e.g., about  $0.7 \text{ mm}^{-1}$ . The plot 500 also shows improvements in the visible/near-infrared range (about 600 nm to about 1300 nm).

**[0120]** Turning again to **FIGURES 3A** through **3C**, an example heat sink 350a is also shown. The heat sink 350a can be attached to, or protrude from an outer surface of, the sensor 301a, thereby providing increased ability for various sensor components to dissipate excess heat. By being on the outer surface of the sensor 301a in certain embodiments, the heat sink 350a can be exposed to the air and thereby facilitate more efficient cooling. In an embodiment, one or more of the emitters (see **FIGURE 1**) generate sufficient heat that inclusion of the heat sink 350a can advantageously allow the sensor 301a to remain safely cooled. The heat sink 350a can include one or more materials that help dissipate heat, such as, for example, aluminum, steel, copper, carbon, combinations of the same, or the like. For example, in some embodiments, the emitter shell 304a can include a heat conducting material that is also readily and relatively inexpensively moldable into desired shapes and forms.

**[0121]** In some embodiments, the heat sink 350a includes metalicized plastic. The metalicized plastic can include aluminum and carbon, for example. The material can allow for improved thermal conductivity and diffusivity, which can increase commercial viability of the heat sink. In some embodiments, the material selected to construct the heat sink 350a can include a thermally conductive liquid crystalline polymer, such as CoolPoly<sup>®</sup> D5506, commercially available from Cool Polymers<sup>®</sup>, Inc. of Warwick, Rhode Island. Such a material can be selected for its electrically non-conductive and dielectric properties so as, for example, to aid in electrical shielding. In an embodiment, the heat sink 350a provides improved heat transfer properties when the sensor 301a is active for short intervals of less than a full day's use. In an embodiment, the heat sink 350a can advantageously provide improved heat transfers in about three (3) to about four (4) minute intervals, for example, although a heat sink 350a can be selected that performs effectively in shorter or longer intervals.

**[0122]** Moreover, the heat sink 350a can have different shapes and configurations for aesthetic as well as for functional purposes. In an embodiment, the heat sink is configured to maximize heat dissipation, for example, by maximizing surface area. In an embodiment, the heat sink 350a is molded into a generally curved surface and includes one or more fins, undulations, grooves, or channels. The example heat sink 350a shown includes fins 351a (see FIGURE 3A).

**[0123]** An alternative shape of a sensor 301b and heat sink 350b is shown in FIGURE 3D. The sensor 301b can include some or all of the features of the sensor 301a. For example, the sensor 301b includes an enclosure 302b formed by an emitter shell 304b and a detector shell 306b, pivotably connected about a pivot 303a. The emitter shell 304b can also include absorbing opaque material on one or more flaps 307b, and the detector shell 306a can also include absorbing opaque material at various areas, such as lower area 308b.

**[0124]** However, the shape of the sensor 301b is different in this embodiment. In particular, the heat sink 350b includes comb protrusions 351b. The comb protrusions 351b are exposed to the air in a similar manner to the fins 351a of the heat sink 350a, thereby facilitating efficient cooling of the sensor 301b.

**[0125]** **FIGURE 3E** illustrates a more detailed example of a detector shell 306b of the sensor 301b. The features described with respect to the detector shell 306b can also be used with the detector shell 306a of the sensor 301a.

**[0126]** As shown, the detector shell 306b includes detectors 316. The detectors 316 can have a predetermined spacing 340 from each other, or a spatial relationship among one another that results in a spatial configuration. This spatial configuration can purposefully create a variation of path lengths among detectors 316 and the emitter discussed above.

**[0127]** In the depicted embodiment, the detector shell 316 can hold multiple (e.g., two, three, four, etc.) photodiode arrays that are arranged in a two-dimensional grid pattern. Multiple photodiode arrays can also be useful to detect light piping (e.g., light that bypasses measurement site 102). In the detector shell 316, walls can be provided to separate the individual photodiode arrays to prevent or reduce mixing of light signals from distinct quadrants. In addition, the detector shell 316 can be covered by windows of transparent material, such as glass, plastic, or the like, to allow maximum or increased transmission of power light captured. In various embodiments, the transparent materials used can also be partially transparent or translucent or can otherwise pass some or all of the optical radiation passing through them. As noted, this window can include some shielding in the form of an embedded grid of wiring, or a conductive layer or coating.

**[0128]** As further illustrated by **FIGURE 3E**, the detectors 316 can have a spatial configuration of a grid. However, the detectors 316 can be arranged in other configurations that vary the path length. For example, the detectors 316 can be arranged in a linear array, a logarithmic array, a two-dimensional array, a zig-zag pattern, or the like. Furthermore, any number of the detectors 316 can be employed in certain embodiments.

**[0129]** **FIGURE 3F** illustrates another embodiment of a sensor 301f. The sensor 301f can include some or all of the features of the sensor 301a of **FIGURE 3A** described above. For example, the sensor 301f includes an enclosure 302f formed by an upper section or emitter shell 304f, which is pivotably connected with a lower section or detector shell 306f around a pivot point 303f. The emitter shell 304f

can also include absorbing opaque material on various areas, such as on one or more flaps 307f, to reduce ambient light entering the sensor 301f. The detector shell 306f can also include absorbing opaque material at various areas, such as a lower area 308f. The sensor 301f also includes a heat sink 350f, which includes fins 351f.

**[0130]** In addition to these features, the sensor 301f includes a flex circuit cover 360, which can be made of plastic or another suitable material. The flex circuit cover 360 can cover and thereby protect a flex circuit (not shown) that extends from the emitter shell 304f to the detector shell 306f. An example of such a flex circuit is illustrated in U.S. Publication No. 2006/0211924, incorporated above (see FIGURE 46 and associated description, which is hereby specifically incorporated by reference). The flex circuit cover 360 is shown in more detail below in FIGURE 17.

**[0131]** In addition, sensors 301a-f has extra length – extends to second joint on finger - Easier to place, harder to move due to cable, better for light piping

**[0132]** FIGURES 4A through 4C illustrate example arrangements of a protrusion 405, which is an embodiment of the protrusion 305 described above. In an embodiment, the protrusion 405 can include a measurement site contact area 470. The measurement site contact area 470 can include a surface that molds body tissue of a measurement site, such as a finger, into a flat or relatively flat surface.

**[0133]** The protrusion 405 can have dimensions that are suitable for a measurement site such as a patient's finger. As shown, the protrusion 405 can have a length 400, a width 410, and a height 430. The length 400 can be from about 9 to about 11 millimeters, e.g., about 10 millimeters. The width 410 can be from about 7 to about 9 millimeters, e.g., about 8 millimeters. The height 430 can be from about 0.5 millimeters to about 3 millimeters, e.g., about 2 millimeters. In an embodiment, the dimensions 400, 410, and 430 can be selected such that the measurement site contact area 470 includes an area of about 80 square millimeters, although larger and smaller areas can be used for different sized tissue for an adult, an adolescent, or infant, or for other considerations.

**[0134]** The measurement site contact area 470 can also include differently shaped surfaces that conform the measurement site into different shapes. For example, the measurement site contact area 470 can be generally curved and/or convex with respect to the measurement site. The measurement site contact area 470 can be other shapes that reduce or even minimize air between the protrusion 405 and or the measurement site. Additionally, the surface pattern of the measurement site contact area 470 can vary from smooth to bumpy, e.g., to provide varying levels of grip.

**[0135]** In **FIGURES 4A** and **4C**, openings or windows 420, 421, 422, and 423 can include a wide variety of shapes and sizes, including for example, generally square, circular, triangular, or combinations thereof. The windows 420, 421, 422, and 423 can be of non-uniform shapes and sizes. As shown, the windows 420, 421, 422, and 423 can be evenly spaced out in a grid like arrangement. Other arrangements or patterns of arranging the windows 420, 421, 422, and 423 are possible. For example, the windows 420, 421, 422, and 423 can be placed in a triangular, circular, or linear arrangement. In some embodiments, the windows 420, 421, 422, and 423 can be placed at different heights with respect to the finger bed 310 of **FIGURE 3**. The windows 420, 421, 422, and 423 can also mimic or approximately mimic a configuration of, or even house, a plurality of detectors.

**[0136]** **FIGURES 6A** through **6D** illustrate another embodiment of a protrusion 605 that can be used as the tissue shaper 105 described above or in place of the protrusions 305, 405 described above. The depicted protrusion 605 is a partially cylindrical lens having a partial cylinder 608 and an extension 610. The partial cylinder 608 can be a half cylinder in some embodiments; however, a smaller or greater portion than half of a cylinder can be used. Advantageously, in certain embodiments, the partially cylindrical protrusion 605 focuses light onto a smaller area, such that fewer detectors can be used to detect the light attenuated by a measurement site.

**[0137]** **FIGURE 6A** illustrates a perspective view of the partially cylindrical protrusion 605. **FIGURE 6B** illustrates a front elevation view of the partially cylindrical protrusion 605. **FIGURE 6C** illustrates a side view of the partially

cylindrical protrusion 605. **FIGURE 6D** illustrates a top view of the partially cylindrical protrusion 605.

**[0138]** Advantageously, in certain embodiments, placing the partially cylindrical protrusion 605 over the photodiodes in any of the sensors described above adds multiple benefits to any of the sensors described above. In one embodiment, the partially cylindrical protrusion 605 penetrates into the tissue and reduces the path length of the light traveling in the tissue, similar to the protrusions described above.

**[0139]** The partially cylindrical protrusion 605 can also collect light from a large surface and focus down the light to a smaller area. As a result, in certain embodiments, signal strength per area of the photodiode can be increased. The partially cylindrical protrusion 605 can therefore facilitate a lower cost sensor because, in certain embodiments, less photodiode area can be used to obtain the same signal strength. Less photodiode area can be realized by using smaller photodiodes or fewer photodiodes (see, e.g., **FIGURE 14**). If fewer or smaller photodiodes are used, the partially cylindrical protrusion 605 can also facilitate an improved SNR of the sensor because fewer or smaller photodiodes can have less dark current.

**[0140]** The dimensions of the partially cylindrical protrusion 605 can vary based on, for instance, a number of photodiodes used with the sensor. Referring to **FIGURE 6C**, the overall height of the partially cylindrical protrusion 605 (measurement "a") in some implementations is about 1 to about 3 mm. A height in this range can allow the partially cylindrical protrusion 605 to penetrate into the pad of the finger or other tissue and reduce the distance that light travels through the tissue. Other heights, however, of the partially cylindrical protrusion 605 can also accomplish this objective. For example, the chosen height of the partially cylindrical protrusion 605 can be selected based on the size of the measurement site, whether the patient is an adult or child, and so on. In an embodiment, the height of the protrusion 605 is chosen to provide as much tissue thickness reduction as possible while reducing or preventing occlusion of blood vessels in the tissue.

**[0141]** Referring to **FIGURE 6D**, the width of the partially cylindrical protrusion 605 (measurement “b”) can be about 3 to about 5 mm. In one embodiment, the width is about 4 mm. In one embodiment, a width in this range provides good penetration of the partially cylindrical protrusion 605 into the tissue to reduce the path length of the light. Other widths, however, of the partially cylindrical protrusion 605 can also accomplish this objective. For example, the width of the partially cylindrical protrusion 605 can vary based on the size of the measurement site, whether the patient is an adult or child, and so on. In addition, the length of the protrusion 605 could be about 10 mm, or about 8 mm to about 12 mm, or smaller than 8 mm or greater than 12 mm.

**[0142]** In certain embodiments, the focal length ( $f$ ) for the partially cylindrical protrusion 605 can be expressed as:  $f = \frac{R}{n-1}$ , where  $R$  is the radius of curvature of the partial cylinder 608 and  $n$  is the index of refraction of the material used. In certain embodiments, the radius of curvature can be between about 1.5 mm and about 2 mm. In another embodiment, the partially cylindrical protrusion 605 can include a material, such as nBK7 glass, with an index of refraction of around 1.5 at 1300 nm, which can provide focal lengths of between about 3 mm and about 4 mm.

**[0143]** A partially cylindrical protrusion 605 having a material with a higher index of refraction such as nSF11 glass (e.g.,  $n=1.75$  at 1300 nm) can provide a shorter focal length and possibly a smaller photodiode chip, but can also cause higher reflections due to the index of refraction mismatch with air. Many types of glass or plastic can be used with index of refraction values ranging from, for example, about 1.4 to about 1.9. The index of refraction of the material of the protrusion 605 can be chosen to improve or optimize the light focusing properties of the protrusion 605. A plastic partially cylindrical protrusion 605 could provide the cheapest option in high volumes but can also have some undesired light absorption peaks at wavelengths higher than 1500 nm. Other focal lengths and materials having different indices of refraction can be used for the partially cylindrical protrusion 605.



**[0144]** Placing a photodiode at a given distance below the partially cylindrical protrusion 605 can facilitate capturing some or all of the light traveling perpendicular to the lens within the active area of the photodiode (see FIGURE 14). Different sizes of the partially cylindrical protrusion 605 can use different sizes of photodiodes. The extension 610 added onto the bottom of the partial cylinder 608 is used in certain embodiments to increase the height of the partially cylindrical protrusion 605. In an embodiment, the added height is such that the photodiodes are at or are approximately at the focal length of the partially cylindrical protrusion 605. In an embodiment, the added height provides for greater thinning of the measurement site. In an embodiment, the added height assists in deflecting light piped through the sensor. This is because light piped around the sensor passes through the side walls of the added height without being directed toward the detectors. The extension 610 can also further facilitate the protrusion 605 increasing or maximizing the amount of light that is provided to the detectors. In some embodiments, the extension 610 can be omitted.

**[0145]** FIGURE 6E illustrates another view of the sensor 301f of FIGURE 3F, which includes an embodiment of a partially cylindrical protrusion 605b. Like the sensor 301A shown in FIGURES 3B and 3C, the sensor 301f includes a finger bed 310f. The finger bed 310f includes a generally curved surface shaped generally to receive tissue, such as a human digit. The finger bed 310f also includes the ridges or channels 314 described above with respect to FIGURES 3B and 3C.

**[0146]** The example of finger bed 310f shown also includes the protrusion 605b, which includes the features of the protrusion 605 described above. In addition, the protrusion 605b also includes chamfered edges 607 on each end to provide a more comfortable surface for a finger to slide across (see also FIGURE 14D). In another embodiment, the protrusion 605b could instead include a single chamfered edge 607 proximal to the ridges 314. In another embodiment, one or both of the chamfered edges 607 could be rounded.

**[0147]** The protrusion 605b also includes a measurement site contact area 670 that can contact body tissue of a measurement site. The protrusion 605b can be removed from or integrated with the finger bed 310f. Interchangeable, differently

shaped protrusions 605b can also be provided, which can correspond to different finger shapes, characteristics, opacity, sizes, or the like.

**[0148]** FIGURES 7A and 7B illustrate block diagrams of sensors 701 that include example arrangements of conductive glass or conductive coated glass for shielding. Advantageously, in certain embodiments, the shielding can provide increased SNR. The features of the sensors 701 can be implemented with any of the sensors 101, 201, 301 described above. Although not shown, the partially cylindrical protrusion 605 of FIGURE 6 can also be used with the sensors 701 in certain embodiments.

**[0149]** For example, referring specifically to **FIGURE 7A**, the sensor 701a includes an emitter housing 704a and a detector housing 706. The emitter housing 704a includes LEDs 104. The detector housing 706a includes a tissue bed 710a with an opening or window 703a, the conductive glass 730a, and one or more photodiodes for detectors 106 provided on a submount 707a.

**[0150]** During operation, a finger 102 can be placed on the tissue bed 710a and optical radiation can be emitted from the LEDs 104. Light can then be attenuated as it passes through or is reflected from the tissue of the finger 102. The attenuated light can then pass through the opening 703a in the tissue bed 710a. Based on the received light, the detectors 106 can provide a detector signal 107, for example, to the front end interface 108 (see FIGURE 1).

**[0151]** In the depicted embodiment, the conductive glass 730 is provided in the opening 703. The conductive glass 730 can thus not only permit light from the finger to pass to the detectors 106, but it can also supplement the shielding of the detectors 106 from noise. The conductive glass 730 can include a stack or set of layers. In **FIGURE 7A**, the conductive glass 730a is shown having a glass layer 731 proximate the finger 102 and a conductive layer 733 electrically coupled to the shielding 790a.

**[0152]** In an embodiment, the conductive glass 730a can be coated with a conductive, transparent or partially transparent material, such as a thin film of indium tin oxide (ITO). To supplement electrical shielding effects of a shielding enclosure 790a, the conductive glass 730a can be electrically coupled to the

shielding enclosure 790a. The conductive glass 730a can be electrically coupled to the shielding 704a based on direct contact or via other connection devices, such as a wire or another component.

**[0153]** The shielding enclosure 790a can be provided to encompass the detectors 106 to reduce or prevent noise. For example, the shielding enclosure 790a can be constructed from a conductive material, such as copper, in the form of a metal cage. The shielding or enclosure a can include an opaque material to not only reduce electrical noise, but also ambient optical noise.

**[0154]** In some embodiments, the shielding enclosure 790a can be constructed in a single manufactured component with or without the use of conductive glass. This form of construction may be useful in order to reduce costs of manufacture as well as assist in quality control of the components. Furthermore, the shielding enclosure 790a can also be used to house various other components, such as sigma delta components for various embodiments of front end interfaces 108.

**[0155]** Referring to **FIGURE 7B**, another block diagram of an example sensor 701b is shown. A tissue bed 710b of the sensor 701b includes a protrusion 705b, which is in the form of a convex bump. The protrusion 705b can include all of the features of the protrusions or tissue shaping materials described above. For example, the protrusion 705b includes a contact area 370 that comes in contact with the finger 102 and which can include one or more openings 703b. One or more components of conductive glass 730b can be provided in the openings 703. For example, in an embodiment, each of the openings 703 can include a separate window of the conductive glass 730b. In an embodiment, a single piece of the conductive glass 730b can be used for some or all of the openings 703b. The conductive glass 730b is smaller than the conductive glass 730a in this particular embodiment.

**[0156]** A shielding enclosure 790b is also provided, which can have all the features of the shielding enclosure 790a. The shielding enclosure 790b is smaller than the shielding enclosure 790a; however, a variety of sizes can be selected for the shielding enclosures 790.

**[0157]** In some embodiments, the shielding enclosure 790b can be constructed in a single manufactured component with or without the use of conductive glass. This form of construction may be useful in order to reduce costs of manufacture as well as assist in quality control of the components. Furthermore, the shielding enclosure 790b can also be used to house various other components, such as sigma delta components for various embodiments of front end interfaces 108.

**[0158]** **FIGURES 8A** through **8D** illustrate a perspective view, side views, and a bottom elevation view of the conductive glass described above with respect to the sensors 701a, 701b. As shown in the perspective view of **FIGURE 8A** and side view of **FIGURE 8B**, the conductive glass 730 includes the electrically conductive material 733 described above as a coating on the glass layer 731 described above to form a stack. In an embodiment where the electrically conductive material 733 includes indium tin oxide, surface resistivity of the electrically conductive material 733 can range approximately from 30 ohms per square inch to 500 ohms per square inch, or approximately 30, 200, or 500 ohms per square inch. As would be understood by a person of skill in the art from the present disclosure, other resistivities can also be used which are less than 30 ohms or more than 500 ohms. Other transparent, electrically conductive materials can be used as the material 733.

**[0159]** Although the conductive material 733 is shown spread over the surface of the glass layer 731, the conductive material 733 can be patterned or provided on selected portions of the glass layer 731. Furthermore, the conductive material 733 can have uniform or varying thickness depending on a desired transmission of light, a desired shielding effect, and other considerations.

**[0160]** In **FIGURE 8C**, a side view of a conductive glass 830a is shown to illustrate an embodiment where the electrically conductive material 733 is provided as an internal layer between two glass layers 731, 835. Various combinations of integrating electrically conductive material 733 with glass are possible. For example, the electrically conductive material 733 can be a layer within a stack of layers. This stack of layers can include one or more layers of glass 731, 835, as

well as one or more layers of conductive material 733. The stack can include other layers of materials to achieve desired characteristics.

**[0161]** In **FIGURE 8D**, a bottom perspective view is shown to illustrate an embodiment where a conductive glass 830b can include conductive material 837 that occupies or covers a portion of a glass layer 839. This embodiment can be useful, for example, to create individual, shielded windows for detectors 106, such as those shown in **FIGURE 3C**. The conductive material 837 can be patterned to include an area 838 to allow light to pass to detectors 106 and one or more strips 841 to couple to the shielding 704 of **FIGURE 7**.

**[0162]** Other configurations and patterns for the conductive material can be used in certain embodiments, such as, for example, a conductive coating lining periphery edges, a conductive coating outlaid in a pattern including a grid or other pattern, a speckled conductive coating, coating outlaid in lines in either direction or diagonally, varied thicknesses from the center out or from the periphery in, or other suitable patterns or coatings that balance the shielding properties with transparency considerations.

**[0163]** **FIGURE 9** depicts an example graph 900 that illustrates comparative results obtained by an example sensor having components similar to those disclosed above with respect to **FIGURES 7** and **8**. The graph 900 depicts the results of the percentage of transmission of varying wavelengths of light for different types of windows used in the sensors described above.

**[0164]** A line 915 on the graph 900 illustrates example light transmission of a window made from plain glass. As shown, the light transmission percentage of varying wavelengths of light is approximately 90% for a window made from plain glass. A line 920 on the graph 900 demonstrates an example light transmission percentage for an embodiment in which a window is made from glass having an ITO coating with a surface resistivity of 500 ohms per square inch. A line 925 on the graph 900 shows an example light transmission for an embodiment in which a window is made from glass that includes a coating of ITO oxide with a surface resistivity of 200 ohms per square inch. A line 930 on the graph 900 shows an example light transmission for an embodiment in which a window is made from

glass that includes a coating of ITO oxide with a surface resistivity of 30 ohms per square inch.

**[0165]** The light transmission percentage for a window with currently available embedded wiring can have a light transmission percentage of approximately 70%. This lower percentage of light transmission can be due to the opacity of the wiring employed in a currently available window with wiring. Accordingly, certain embodiments of glass coatings described herein can employ, for example, ITO coatings with different surface resistivity depending on the desired light transmission, wavelengths of light used for measurement, desired shielding effect, and other criteria.

**[0166]** **FIGURES 10A** through **10B** illustrate comparative noise floors of example implementations of the sensors described above. Noise can include optical noise from ambient light and electro-magnetic noise, for example, from surrounding electrical equipment. In **FIGURE 10A**, a graph 1000 depicts possible noise floors for different frequencies of noise for an embodiment in which one of the sensors described above included separate windows for four (4) detectors 106. One or more of the windows included an embedded grid of wiring as a noise shield. Symbols 1030 - 1033 illustrate the noise floor performance for this embodiment. As can be seen, the noise floor performance can vary for each of the openings and based on the frequency of the noise.

**[0167]** In **FIGURE 10B**, a graph 1050 depicts a noise floor for frequencies of noise 1070 for an embodiment in which the sensor included separate openings for four (4) detectors 106 and one or more windows that include an ITO coating. In this embodiment, a surface resistivity of the ITO used was about 500 ohms per square inch. Symbols 1080 - 1083 illustrate the noise floor performance for this embodiment. As can be seen, the noise floor performance for this embodiment can vary less for each of the openings and provide lower noise floors in comparison to the embodiment of **FIGURE 10A**.

**[0168]** **FIGURE 11A** illustrates an example structure for configuring the set of optical sources of the emitters described above. As shown, an emitter 104 can include a driver 1105, a thermistor 1120, a set of top-emitting LEDs 1102 for

emitting red and/or infrared light, a set of side-emitting LEDs 1104 for emitting near infrared light, and a submount 1106.

**[0169]** The thermistor 1120 can be provided to compensate for temperature variations. For example, the thermistor 1120 can be provided to allow for wavelength centroid and power drift of LEDs 1102 and 1104 due to heating. In addition, other thermistors (~~not shown~~) can be employed, for example, to measure a temperature of a measurement site. The temperature can be displayed on a display device and used by a caregiver. Such a temperature can also be helpful in correcting for wavelength drift due to changes in water absorption, which can be temperature dependent, thereby providing more accurate data useful in detecting blood analytes like glucose. In addition, using a thermistor or other type of temperature sensitive device may be useful for detecting extreme temperatures at the measurement site that are too hot or too cold. The presence of low perfusion may also be detected, for example, when the finger of a patient has become too cold. Moreover, shifts in temperature at the measurement site can alter the absorption spectrum of water and other tissue in the measurement site. A thermistor's temperature reading can be used to adjust for the variations in absorption spectrum changes in the measurement site.

**[0170]** The driver 1105 can provide pulses of current to the emitter 1104. In an embodiment, the driver 1105 drives the emitter 1104 in a progressive fashion, for example, in an alternating manner based on a control signal from, for example, a processor (e.g., the processor 110). For example, the driver 1105 can drive the emitter 1104 with a series of pulses to about 1 milliwatt (mW) for visible light to light at about 1300 nm and from about 40 mW to about 100 mW for light at about 1600 nm to about 1700 nm. However, a wide number of driving powers and driving methodologies can be used. The driver 1105 can be synchronized with other parts of the sensor and can minimize or reduce any jitter in the timing of pulses of optical radiation emitted from the emitter 1104. In some embodiments, the driver 1105 is capable of driving the emitter 1104 to emit an optical radiation in a pattern that varies by less than about 10 parts-per-million; however other amounts of variation can be used.

**[0171]** The submount 1106 provides a support structure in certain embodiments for aligning the top-emitting LEDs 1102 and the side-emitting LEDs 1104 so that their optical radiation is transmitted generally towards the measurement site. In some embodiments, the submount 1106 is also constructed of aluminum nitride (AlN) or beryllium oxide (BEO) for heat dissipation, although other materials or combinations of materials suitable for the submount 1106 can be used.

**[0172]** **FIGURE 11B** illustrates a configuration of emitting optical radiation into a measurement site for measuring a blood constituent or analyte like glucose. In some embodiments, emitter 104 may be driven in a progressive fashion to minimize noise and increase SNR of sensor 101. For example, emitter 104 may be driven based on a progression of power/current delivered to LEDs 1102 and 1104.

**[0173]** In some embodiments, emitter 104 may be configured to emit pulses centered about 905 nm, about 1050 nm, about 1200 nm, about 1300 nm, about 1330 nm, about 1610 nm, about 1640 nm, and about 1665 nm. In another embodiment, the emitter 104 may emit optical radiation ranging from about 860 nm to about 950 nm, about 950 nm to about 1100 nm, about 1100 nm to about 1270 nm, about 1250 nm to about 1350 nm, about 1300 nm to about 1360 nm, and about 1590 nm to about 1700 nm. Of course, emitter 104 may be configured to transmit any of a variety of wavelengths of visible, or near-infrared optical radiation.

**[0174]** For purposes of illustration, **FIGURE 11B** shows a sequence of pulses of light at wavelengths of around 905 nm, around 1200 nm, around 1300 nm, and around 1330 nm from top emitting LEDs 1102. **FIGURE 11B** also shows that emitter 104 may then emit pulses centered at around 1630 nm, around 1660 nm, and around 1615 nm from side emitting LEDs 1104. Emitter 104 may be progressively driven at higher power/current. This progression may allow driver circuit 105 to stabilize in its operations, and thus, provide a more stable current/power to LEDs 1102 and 1104.

**[0175]** For example, as shown in **FIGURE 11B**, the sequence of optical radiation pulses are shown having a logarithmic-like progression in power/current. In some embodiments, the timing of these pulses is based on a cycle of about 400



slots running at 48 kHz (e.g. each time slot may be approximately 0.02 ms or 20 microseconds). An artisan will recognize that term “slots” includes its ordinary meaning, which includes a time period that may also be expressed in terms of a frequency. In the example shown, pulses from top emitting LEDs 1102 may have a pulse width of about 40 time slots (e.g., about 0.8 ms) and an off period of about 4 time slots in between. In addition, pulses from side emitting LEDs 1104 (e.g., or a laser diode) may have a pulse width of about 60 time slots (e.g., about 1.25 ms) and a similar off period of about 4 time slots. A pause of about 70 time slots (e.g. 1.5 ms) may also be provided in order to allow driver circuit 1105 to stabilize after operating at higher current/power.

**[0176]** As shown in **FIGURE 11B**, top emitting LEDs 1102 may be initially driven with a power to approximately 1 mW at a current of about 20-100 mA. Power in these LEDs may also be modulated by using a filter or covering of black dye to reduce power output of LEDs. In this example, top emitting LEDs 1102 may be driven at approximately 0.02 to 0.08 mW. The sequence of the wavelengths may be based on the current requirements of top emitting LEDs 502 for that particular wavelength. Of course, in other embodiments, different wavelengths and sequences of wavelengths may be output from emitter 104.

**[0177]** Subsequently, side emitting LEDs 1104 may be driven at higher powers, such as about 40-100 mW and higher currents of about 600-800 mA. This higher power may be employed in order to compensate for the higher opacity of tissue and water in measurement site 102 to these wavelengths. For example, as shown, pulses at about 1630 nm, about 1660 nm, and about 1615 nm may be output with progressively higher power, such as at about 40 mW, about 50 mW, and about 60 mW, respectively. In this embodiment, the order of wavelengths may be based on the optical characteristics of that wavelength in tissue as well as the current needed to drive side emitting LEDs 1104. For example, in this embodiment, the optical pulse at about 1615 nm is driven at the highest power due to its sensitivity in detecting analytes like glucose and the ability of light at this wavelength to penetrate tissue. Of course, different wavelengths and sequences of wavelengths may be output from emitter 104.

**[0178]** As noted, this progression may be useful in some embodiments because it allows the circuitry of driver circuit 1105 to stabilize its power delivery to LEDs 1102 and 1104. Driver circuit 1105 may be allowed to stabilize based on the duty cycle of the pulses or, for example, by configuring a variable waiting period to allow for stabilization of driver circuit 1105. Of course, other variations in power/current and wavelength may also be employed in the present disclosure.

**[0179]** Modulation in the duty cycle of the individual pulses may also be useful because duty cycle can affect the signal noise ratio of the system 100. That is, as the duty cycle is increased so may the signal to noise ratio.

**[0180]** Furthermore, as noted above, driver circuit 1105 may monitor temperatures of the LEDs 1102 and 1104 using the thermistor 1120 and adjust the output of LEDs 1102 and 1104 accordingly. Such a temperature may be to help sensor 101 correct for wavelength drift due to changes in water absorption, which can be temperature dependent.

**[0181]** **FIGURE 11C** illustrates another exemplary emitter that may be employed in the sensor according to an embodiment of the disclosure. As shown, the emitter 104 can include components mounted on a substrate 1108 and on submount 1106. In particular, top-emitting LEDs 1102 for emitting red and/or infrared light may be mounted on substrate 1108. Side emitting LEDs 1104 may be mounted on submount 1106. As noted, side-emitting LEDs 1104 may be included in emitter 104 for emitting near infrared light.

**[0182]** As also shown, the sensor of **FIGURE 11C** may include a thermistor 1120. As noted, the thermistor 1120 can be provided to compensate for temperature variations. The thermistor 1120 can be provided to allow for wavelength centroid and power drift of LEDs 1102 and 1104 due to heating. In addition, other thermistors (not shown) can be employed, for example, to measure a temperature of a measurement site. Such a temperature can be helpful in correcting for wavelength drift due to changes in water absorption, which can be temperature dependent, thereby providing more accurate data useful in detecting blood analytes like glucose.

**[0183]** In some embodiments, the emitter 104 may be implemented without the use of side emitting LEDs. For example, certain blood constituents, such as total hemoglobin, can be measured by embodiments of the disclosure without the use of side emitting LEDs. **FIGURE 11D** illustrates another exemplary emitter that may be employed in the sensor according to an embodiment of the disclosure. In particular, an emitter 104 that is configured for a blood constituent, such as total hemoglobin, is shown. The emitter 104 can include components mounted on a substrate 1108. In particular, top-emitting LEDs 1102 for emitting red and/or infrared light may be mounted on substrate 1108.

**[0184]** As also shown, the emitter of **FIGURE 11D** may include a thermistor 1120. The thermistor 1120 can be provided to compensate for temperature variations. The thermistor 1120 can be provided to allow for wavelength centroid and power drift of LEDs 1102 due to heating.

**[0185]** **FIGURE 12A** illustrates a detector submount 1200 having photodiode detectors that are arranged in a grid pattern on the detector submount 1200 to capture light at different quadrants from a measurement site. One detector submount 1200 can be placed under each window of the sensors described above, or multiple windows can be placed over a single detector submount 1200. The detector submount 1200 can also be used with the partially cylindrical protrusion 605 described above with respect to **FIGURE 6**.

**[0186]** The detectors include photodiode detectors 1-4 that are arranged in a grid pattern on the submount 1200 to capture light at different quadrants from the measurement site. As noted, other patterns of photodiodes, such as a linear row, or logarithmic row, can also be employed in certain embodiments.

**[0187]** As shown, the detectors 1-4 may have a predetermined spacing from each other, or spatial relationship among one another that result in a spatial configuration. This spatial configuration can be configured to purposefully create a variation of path lengths among detectors 106 and the point light source discussed above.

**[0188]** Detectors may hold multiple (e.g., two, three, four, etc.) photodiode arrays that are arranged in a two-dimensional grid pattern. Multiple photodiode

arrays may also be useful to detect light piping (i.e., light that bypasses measurement site 102). As shown, walls may separate the individual photodiode arrays to prevent mixing of light signals from distinct quadrants. In addition, as noted, the detectors may be covered by windows of transparent material, such as glass, plastic, etc., to allow maximum transmission of power light captured. As noted, this window may comprise some shielding in the form of an embedded grid of wiring, or a conductive layer or coating.

**[0189] FIGURES 12B through 12D** illustrate a simplified view of exemplary arrangements and spatial configurations of photodiodes for detectors 106. As shown, detectors 106 may comprise photodiode detectors 1-4 that are arranged in a grid pattern on detector submount 1200 to capture light at different quadrants from measurement site 102.

**[0190]** As noted, other patterns of photodiodes may also be employed in embodiments of the present disclosure, including, for example, stacked or other configurations recognizable to an artisan from the disclosure herein. For example, detectors 106 may be arranged in a linear array, a logarithmic array, a two-dimensional array, and the like. Furthermore, an artisan will recognize from the disclosure herein that any number of detectors 106 may be employed by embodiments of the present disclosure.

**[0191]** For example, as shown in **FIGURE 12B**, detectors 106 may comprise photodiode detectors 1-4 that are arranged in a substantially linear configuration on submount 1200. In this embodiment shown, photodiode detectors 1-4 are substantially equally spaced apart (e.g., where the distance  $D$  is substantially the same between detectors 1-4).

**[0192]** In **FIGURE 12C**, photodiode detectors 1-4 may be arranged in a substantially linear configuration on submount 1200, but may employ a substantially progressive, substantially logarithmic, or substantially semi-logarithmic spacing (e.g., where distances  $D1 > D2 > D3$ ). This arrangement or pattern may be useful for use on a patient's finger and where the thickness of the finger gradually increases.

**[0193]** In **FIGURE 12D**, a different substantially grid pattern on submount 1200 of photodiode detectors 1-4 is shown. As noted, other patterns of detectors may also be employed in embodiments of the present invention.

**[0194]** **FIGURES 12E through 12H** illustrate several embodiments of photodiodes that may be used in detectors 106. As shown in these figures, a photodiode 1202 of detector 106 may comprise a plurality of active areas 1204. These active areas 204 may be coupled together via a common cathode 1206 or anode 1208 in order to provide a larger effective detection area.

**[0195]** In particular, as shown in **FIGURE 12E**, photodiode 1202 may comprise two (2) active areas 1204a and 1204b. In **FIGURE 12F**, photodiode 1202 may comprise four (4) active areas 1204c-f. In **FIGURE 12G**, photodiode 1202 may comprise three (3) active areas 1204g-i. In **FIGURE 12H**, photodiode 1202 may comprise nine (9) active areas 1204j-r. The use of smaller active areas may be useful because smaller active areas can be easier to fabricate and can be fabricated with higher purity. However, one skilled in the art will recognize that various sizes of active areas may be employed in the photodiode 1202.

**[0196]** **FIGURE 13** illustrates an example multi-stream process 1300. The multi-stream process 1300 can be implemented by the data collection system 100 and/or by any of the sensors described above. As shown, a control signal from a signal processor 1310 controls a driver 1305. In response, an emitter 1304 generates a pulse sequence 1303 from its emitter (e.g., its LEDs) into a measurement site or sites 1302. As described above, in some embodiments, the pulse sequence 1303 is controlled to have a variation of about 10 parts per million or less. Of course, depending on the analyte desired, the tolerated variation in the pulse sequence 1303 can be greater (or smaller).

**[0197]** In response to the pulse sequence 1300, detectors 1 to n (n being an integer) in a detector 1306 capture optical radiation from the measurement site 1302 and provide respective streams of output signals. Each signal from one of detectors 1-n can be considered a stream having respective time slots corresponding to the optical pulses from emitter sets 1-n in the emitter 1304.

Although  $n$  emitters and  $n$  detectors are shown, the number of emitters and detectors need not be the same in certain implementations.

**[0198]** A front end interface 1308 can accept these multiple streams from detectors 1- $n$  and deliver one or more signals or composite signal(s) back to the signal processor 1310. A stream from the detectors 1- $n$  can thus include measured light intensities corresponding to the light pulses emitted from the emitter 1304.

**[0199]** The signal processor 1310 can then perform various calculations to measure the amount of glucose and other analytes based on these multiple streams of signals. In order to help explain how the signal processor 1310 can measure analytes like glucose, a primer on the spectroscopy employed in these embodiments will now be provided.

**[0200]** Spectroscopy is premised upon the Beer-Lambert law. According to this law, the properties of a material, e.g., glucose present in a measurement site, can be deterministically calculated from the absorption of light traveling through the material. Specifically, there is a logarithmic relation between the transmission of light through a material and the concentration of a substance and also between the transmission and the length of the path traveled by the light. As noted, this relation is known as the Beer-Lambert law.

**[0201]** The Beer-Lambert law is usually written as:

**[0202]** Absorbance  $A = m \cdot b \cdot c$ , where:

**[0203]**  $m$  is the wavelength-dependent molar absorptivity coefficient (usually expressed in units of  $M^{-1} \text{ cm}^{-1}$ );

**[0204]**  $b$  is the mean path length; and

**[0205]**  $c$  is the analyte concentration (e.g., the desired parameter).

**[0206]** In spectroscopy, instruments attempt to obtain the analyte concentration ( $c$ ) by relating absorbance ( $A$ ) to transmittance ( $T$ ). Transmittance is a proportional value defined as:

**[0207]**  $T = I / I_0$ , where:

**[0208]**  $I$  is the light intensity measured by the instrument from the measurement site; and

**[0209]**  $I_0$  is the initial light intensity from the emitter.

**[0210]** Absorbance (A) can be equated to the transmittance (T) by the equation:

**[0211]**  $A = -\log T$

**[0212]** Therefore, substituting equations from above:

**[0213]**  $A = -\log (I / I_0)$

**[0214]** In view of this relationship, spectroscopy thus relies on a proportional-based calculation of  $-\log(I / I_0)$  and solving for analyte concentration (c).

**[0215]** Typically, in order to simplify the calculations, spectroscopy will use detectors that are at the same location in order to keep the path length (b) a fixed, known constant. In addition, spectroscopy will employ various mechanisms to definitively know the transmission power ( $I_0$ ), such as a photodiode located at the light source. This architecture can be viewed as a single channel or single stream sensor, because the detectors are at a single location.

**[0216]** However, this scheme can encounter several difficulties in measuring analytes, such as glucose. This can be due to the high overlap of absorption of light by water at the wavelengths relevant to glucose as well as other factors, such as high self-noise of the components.

**[0217]** Embodiments of the present disclosure can employ a different approach that in part allows for the measurement of analytes like glucose. Some embodiments can employ a bulk, non-pulsatile measurement in order to confirm or validate a pulsatile measurement. In addition, both the non-pulsatile and pulsatile measurements can employ, among other things, the multi-stream operation described above in order to attain sufficient SNR. In particular, a single light source having multiple emitters can be used to transmit light to multiple detectors having a spatial configuration.

**[0218]** A single light source having multiple emitters can allow for a range of wavelengths of light to be used. For example, visible, infrared, and near infrared wavelengths can be employed. Varying powers of light intensity for different wavelengths can also be employed.

**[0219]** Secondly, the use of multiple-detectors in a spatial configuration allow for a bulk measurement to confirm or validate that the sensor is positioned

correctly. This is because the multiple locations of the spatial configuration can provide, for example, topology information that indicates where the sensor has been positioned. Currently available sensors do not provide such information. For example, if the bulk measurement is within a predetermined range of values, then this can indicate that the sensor is positioned correctly in order to perform pulsatile measurements for analytes like glucose. If the bulk measurement is outside of a certain range or is an unexpected value, then this can indicate that the sensor should be adjusted, or that the pulsatile measurements can be processed differently to compensate, such as using a different calibration curve or adjusting a calibration curve. This feature and others allow the embodiments to achieve noise cancellation and noise reduction, which can be several times greater in magnitude than what is achievable by currently available technology.

**[0220]** In order to help illustrate aspects of the multi-stream measurement approach, the following example derivation is provided. Transmittance (T) can be expressed as:

$$\textbf{[0221] } T = e^{-m*b*c}$$

**[0222]** In terms of light intensity, this equation can also be rewritten as:

$$\textbf{[0223] } I / I_o = e^{-m*b*c}$$

**[0224]** Or, at a detector, the measured light (I) can be expressed as:

$$\textbf{[0225] } I = I_o * e^{-m*b*c}$$

**[0226]** As noted, in the present disclosure, multiple detectors (1 to n) can be employed, which results in  $I_1 \dots I_n$  streams of measurements. Assuming each of these detectors have their own path lengths,  $b_1 \dots b_n$ , from the light source, the measured light intensities can be expressed as:

$$\textbf{[0227] } I_n = I_o * e^{-m*b_n*c}$$

**[0228]** The measured light intensities at any two different detectors can be referenced to each other. For example:

$$\textbf{[0229] } I_1/I_n = (I_o * e^{-mb_1c}) / (I_o * e^{-mb_nc})$$

**[0230]** As can be seen, the terms,  $I_o$ , cancel out and, based on exponent algebra, the equation can be rewritten as:



**[0231]**  $I_1/I_n = e^{-m(b_1-b_n)c}$

**[0232]** From this equation, the analyte concentration (c) can now be derived from bulk signals  $I_1 \dots I_n$  and knowing the respective mean path lengths  $b_1$  and  $b_n$ . This scheme also allows for the cancelling out of  $I_0$ , and thus, noise generated by the emitter 1304 can be cancelled out or reduced. In addition, since the scheme employs a mean path length difference, any changes in mean path length and topological variations from patient to patient are easily accounted. Furthermore, this bulk-measurement scheme can be extended across multiple wavelengths. This flexibility and other features allow embodiments of the present disclosure to measure blood analytes like glucose.

**[0233]** For example, as noted, the non-pulsatile, bulk measurements can be combined with pulsatile measurements to more accurately measure analytes like glucose. In particular, the non-pulsatile, bulk measurement can be used to confirm or validate the amount of glucose, protein, etc. in the pulsatile measurements taken at the tissue at the measurement site(s) 1302. The pulsatile measurements can be used to measure the amount of glucose, hemoglobin, or the like that is present in the blood. Accordingly, these different measurements can be combined to thus determine analytes like blood glucose.

**[0234]** **FIGURE 14A** illustrates an embodiment of a detector submount 1400a positioned beneath the partially cylindrical protrusion 605 of FIGURE 6 (or alternatively, the protrusion 605b). The detector submount 1400a includes two rows 1408a of detectors 1410a. The partially cylindrical protrusion 605 can facilitate reducing the number and/or size of detectors used in a sensor because the protrusion 605 can act as a lens that focuses light onto a smaller area.

**[0235]** To illustrate, in some sensors that do not include the partially cylindrical protrusion 605, sixteen detectors can be used, including four rows of four detectors each. Multiple rows of detectors can be used to measure certain analytes, such as glucose or total hemoglobin, among others. Multiple rows of detectors can also be used to detect light piping (e.g., light that bypasses the measurement site). However, using more detectors in a sensor can add cost, complexity, and noise to the sensor.

**[0236]** Applying the partially cylindrical protrusion 605 to such a sensor, however, could reduce the number of detectors or rows of detectors used while still receiving the substantially same amount of light, due to the focusing properties of the protrusion 605 (see FIGURE 14B). This is the example situation illustrated in **FIGURE 14**—two rows 1408a of detectors 1410a are used instead of four. Advantageously, in certain embodiments, the resulting sensor can be more cost effective, have less complexity, and have an improved SNR, due to fewer and/or smaller photodiodes.

**[0237]** In other embodiments, using the partially cylindrical protrusion 605 can allow the number of detector rows to be reduced to one or three rows of four detectors. The number of detectors in each row can also be reduced. Alternatively, the number of rows might not be reduced but the size of the detectors can be reduced. Many other configurations of detector rows and sizes can also be provided.

**[0238]** **FIGURE 14B** depicts a front elevation view of the partially cylindrical protrusion 605 (or alternatively, the protrusion 605b) that illustrates how light from emitters (not shown) can be focused by the protrusion 605 onto detectors. The protrusion 605 is placed above a detector submount 1400b having one or more detectors 1410b disposed thereon. The submount 1400b can include any number of rows of detectors 1410, although one row is shown.

**[0239]** Light, represented by rays 1420, is emitted from the emitters onto the protrusion 605. These light rays 1420 can be attenuated by body tissue (not shown). When the light rays 1420 enter the protrusion 605, the protrusion 605 acts as a lens to refract the rays into rays 1422. This refraction is caused in certain embodiments by the partially cylindrical shape of the protrusion 605. The refraction causes the rays 1422 to be focused or substantially focused on the one or more detectors 1410b. Since the light is focused on a smaller area, a sensor including the protrusion 605 can include fewer detectors to capture the same amount of light compared with other sensors.

**[0240]** **FIGURE 14C** illustrates another embodiment of a detector submount 1400c, which can be disposed under the protrusion 605b (or alternatively,

the protrusion 605). The detector submount 1400c includes a single row 1408c of detectors 1410c. The detectors are electrically connected to conductors 1412c, which can be gold, silver, copper, or any other suitable conductive material.

**[0241]** The detector submount 1400c is shown positioned under the protrusion 605b in a detector subassembly 1450 illustrated in **FIGURE 14D**. A top-down view of the detector subassembly 1450 is also shown in **FIGURE 14E**. In the detector subassembly 1450, a cylindrical housing 1430 is disposed on the submount 1400c. The cylindrical housing 1430 includes a transparent cover 1432, upon which the protrusion 605b is disposed. Thus, as shown in **FIGURE 14D**, a gap 1434 exists between the detectors 1410c and the protrusion 605b. The height of this gap 1434 can be chosen to increase or maximize the amount of light that impinges on the detectors 1410c.

**[0242]** The cylindrical housing 1430 can be made of metal, plastic, or another suitable material. The transparent cover 1432 can be fabricated from glass or plastic, among other materials. The cylindrical housing 1430 can be attached to the submount 1400c at the same time or substantially the same time as the detectors 1410c to reduce manufacturing costs. A shape other than a cylinder can be selected for the housing 1430 in various embodiments.

**[0243]** In certain embodiments, the cylindrical housing 1430 (and transparent cover 1432) forms an airtight or substantially airtight or hermetic seal with the submount 1400c. As a result, the cylindrical housing 1430 can protect the detectors 1410c and conductors 1412c from fluids and vapors that can cause corrosion. Advantageously, in certain embodiments, the cylindrical housing 1430 can protect the detectors 1410c and conductors 1412c more effectively than currently-available resin epoxies, which are sometimes applied to solder joints between conductors and detectors.

**[0244]** In embodiments where the cylindrical housing 1430 is at least partially made of metal, the cylindrical housing 1430 can provide noise shielding for the detectors 1410c. For example, the cylindrical housing 1430 can be soldered to a ground connection or ground plane on the submount 1400c, which allows the cylindrical housing 1430 to reduce noise. In another embodiment, the transparent

cover 1432 can include a conductive material or conductive layer, such as conductive glass or plastic. The transparent cover 1432 can include any of the features of the noise shields 790 described above.

**[0245]** The protrusion 605b includes the chamfered edges 607 described above with respect to FIGURE 6E. These chamfered edges 607 can allow a patient to more comfortably slide a finger over the protrusion 605b when inserting the finger into the sensor 301f.

**[0246]** FIGURE 14F illustrates a portion of the detector shell 306f, which includes the detectors 1410c on the substrate 1400c. The substrate 1400c is enclosed by a shielding enclosure 1490, which can include the features of the shielding enclosures 790a, 790b described above (see also FIGURE 17). The shielding enclosure 1490 can be made of metal. The shielding enclosure 1490 includes a window 1492a above the detectors 1410c, which allows light to be transmitted onto the detectors 1410c.

**[0247]** A noise shield 1403 is disposed above the shielding enclosure 1490. The noise shield 1403, in the depicted embodiment, includes a window 1492a corresponding to the window 1492a. Each of the windows 1492a, 1492b can include glass, plastic, or can be an opening without glass or plastic. In some embodiments, the windows 1492a, 1492b may be selected to have different sizes or shapes from each other.

**[0248]** The noise shield 1403 can include any of the features of the conductive glass described above. In the depicted embodiment, the noise shield 1403 extends about three-quarters of the length of the detector shell 306f. In other embodiments, the noise shield 1403 could be smaller or larger. The noise shield 1403 could, for instance, merely cover the detectors 1410c, the submount 1400c, or a portion thereof. The noise shield 1403 also includes a stop 1413 for positioning a measurement site within the sensor 301f. Advantageously, in certain embodiments, the noise shield 1403 can reduce noise caused by light piping.

**[0249]** A thermistor 1470 is also shown. The thermistor 1470 is attached to the submount 1400c and protrudes above the noise shield 1403. As described above, the thermistor 1470 can be employed to measure a temperature of a

measurement site. Such a temperature can be helpful in correcting for wavelength drift due to changes in water absorption, which can be temperature dependent, thereby providing more accurate data useful in detecting blood analytes like glucose.

**[0250]** In the depicted embodiment, the detectors 1410c are not enclosed in the cylindrical housing 1430. In an alternative embodiment, the cylindrical housing 1430 encloses the detectors 1410c and is disposed under the noise shield 1403. In another embodiment, the cylindrical housing 1430 encloses the detectors 1410c and the noise shield 1403 is not used. If both the cylindrical housing 1403 and the noise shield 1403 are used, either or both can have noise shielding features.

**[0251]** **FIGURE 14G** illustrates the detector shell 306f of **FIGURE 14F**, with the finger bed 310f disposed thereon. **FIGURE 14H** illustrates the detector shell 306f of **FIGURE 14G**, with the protrusion 605b disposed in the finger bed 310f.

**[0252]** **FIGURE 14I** illustrates a cutaway view of the sensor 301f. Not all features of the sensor 301f are shown, such as the protrusion 605b. Features shown include the emitter and detector shells 304f, 306f, the flaps 307f, the heat sink 350f and fins 351f, the finger bed 310f, and the noise shield 1403.

**[0253]** In addition to these features, emitters 1404 are depicted in the emitter shell 304f. The emitters 1404 are disposed on a submount 1401, which is connected to a circuit board 1419. The emitters 1404 are also enclosed within a cylindrical housing 1480. The cylindrical housing 1480 can include all of the features of the cylindrical housing 1430 described above. For example, the cylindrical housing 1480 can be made of metal, can be connected to a ground plane of the submount 1401 to provide noise shielding, and can include a transparent cover 1482.

**[0254]** The cylindrical housing 1480 can also protect the emitters 1404 from fluids and vapors that can cause corrosion. Moreover, the cylindrical housing 1480 can provide a gap between the emitters 1404 and the measurement site (not shown), which can allow light from the emitters 1404 to even out or average out before reaching the measurement site.

**[0255]** The heat sink 350f, in addition to including the fins 351f, includes a protuberance 352f that extends down from the fins 351f and contacts the submount 1401. The protuberance 352f can be connected to the submount 1401, for example, with thermal paste or the like. The protuberance 352f can sink heat from the emitters 1404 and dissipate the heat via the fins 351f.

**[0256]** **FIGURES 15A and 15B** illustrate embodiments of sensor portions 1500A, 1500B that include alternative heat sink features to those described above. These features can be incorporated into any of the sensors described above. For example, any of the sensors above can be modified to use the heat sink features described below instead of or in addition to the heat sink features of the sensors described above.

**[0257]** The sensor portions 1500A, 1500B shown include LED emitters 1504; however, for ease of illustration, the detectors have been omitted. The sensor portions 1500A, 1500B shown can be included, for example, in any of the emitter shells described above.

**[0258]** The LEDs 1504 of the sensor portions 1500A, 1500B are connected to a substrate or submount 1502. The submount 1502 can be used in place of any of the submounts described above. The submount 1502 can be a non-electrically conducting material made of any of a variety of materials, such as ceramic, glass, or the like. A cable 1512 is attached to the submount 1502 and includes electrical wiring 1514, such as twisted wires and the like, for communicating with the LEDs 1504. The cable 1512 can correspond to the cables 212 described above.

**[0259]** Although not shown, the cable 1512 can also include electrical connections to a detector. Only a portion of the cable 1512 is shown for clarity. The depicted embodiment of the cable 1512 includes an outer jacket 1510 and a conductive shield 1506 disposed within the outer jacket 1510. The conductive shield 1506 can be a ground shield or the like that is made of a metal such as braided copper or aluminum. The conductive shield 1506 or a portion of the conductive shield 1506 can be electrically connected to the submount 1502 and can reduce noise in the signal generated by the sensor 1500A, 1500B by reducing RF

coupling with the wires 1514. In alternative embodiments, the cable 1512 does not have a conductive shield. For example, the cable 1512 could be a twisted pair cable or the like, with one wire of the twisted pair used as a heat sink.

**[0260]** Referring specifically to **FIGURE 15A**, in certain embodiments, the conductive shield 1506 can act as a heat sink for the LEDs 1504 by absorbing thermal energy from the LEDs 1504 and/or the submount 1502. An optional heat insulator 1520 in communication with the submount 1502 can also assist with directing heat toward the conductive shield 1506. The heat insulator 1520 can be made of plastic or another suitable material. Advantageously, using the conductive shield 1506 in the cable 1512 as a heat sink can, in certain embodiments, reduce cost for the sensor.

**[0261]** Referring to **FIGURE 15B**, the conductive shield 1506 can be attached to both the submount 1502 and to a heat sink layer 1530 sandwiched between the submount 1502 and the optional insulator 1520. Together, the heat sink layer 1530 and the conductive shield 1506 in the cable 1512 can absorb at least part of the thermal energy from the LEDs and/or the submount 1502.

**[0262]** **FIGURES 15C** and **15D** illustrate implementations of a sensor portion 1500C that includes the heat sink features of the sensor portion 1500A described above with respect to **FIGURE 15A**. The sensor portion 1500C includes the features of the sensor portion 1500A, except that the optional insulator 1520 is not shown. **FIGURE 15D** is a side cutaway view of the sensor portion 1500C that shows the emitters 1504.

**[0263]** The cable 1512 includes the outer jacket 1510 and the conductive shield 1506. The conductive shield 1506 is soldered to the submount 1502, and the solder joint 1561 is shown. In some embodiments, a larger solder joint 1561 can assist with removing heat more rapidly from the emitters 1504. Various connections 1563 between the submount 1502 and a circuit board 1519 are shown. In addition, a cylindrical housing 1580, corresponding to the cylindrical housing 1480 of **FIGURE 14I**, is shown protruding through the circuit board 1519. The emitters 1504 are enclosed in the cylindrical housing 1580.

**[0264]** FIGURES 15E and 15F illustrate implementations of a sensor portion 1500E that includes the heat sink features of the sensor portion 1500B described above with respect to FIGURE 15B. The sensor portion 1500E includes the heat sink layer 1530. The heat sink layer 1530 can be a metal plate, such as a copper plate or the like. The optional insulator 1520 is not shown. **FIGURE 15F** is a side cutaway view of the sensor portion 1500E that shows the emitters 1504.

**[0265]** In the depicted embodiment, the conductive shield 1506 of the cable 1512 is soldered to the heat sink layer 1530 instead of the submount 1502. The solder joint 1565 is shown. In some embodiments, a larger solder joint 1565 can assist with removing heat more rapidly from the emitters 1504. Various connections 1563 between the submount 1502 and a circuit board 1519 are shown. In addition, the cylindrical housing 1580 is shown protruding through the circuit board 1519. The emitters 1504 are enclosed in the cylindrical housing 1580.

**[0266]** FIGURES 15G and 15H illustrate embodiments of connector features that can be used with any of the sensors described above with respect to FIGURES 1 through 15F. Referring to **FIGURE 15G**, the circuit board 1519 includes a female connector 1575 that mates with a male connector 1577 connected to a daughter board 1587. The daughter board 1587 includes connections to the electrical wiring 1514 of the cable 1512. The connected boards 1519, 1587 are shown in **FIGURE 15H**. Also shown is a hole 1573 that can receive the cylindrical housing 1580 described above.

**[0267]** Advantageously, in certain embodiments, using a daughter board 1587 to connect to the circuit board 1519 can enable connections to be made more easily to the circuit board 1519. In addition, using separate boards can be easier to manufacture than a single circuit board 1519 with all connections soldered to the circuit board 1519.

**[0268]** **FIGURE 15I** illustrates an exemplary architecture for front-end interface 108 as a transimpedance-based front-end. As noted, front-end interfaces 108 provide an interface that adapts the output of detectors 106 into a form that can be handled by signal processor 110. As shown in this figure, sensor 101 and front-end interfaces 108 may be integrated together as a single component, such as an



integrated circuit. Of course, one skilled in the art will recognize that sensor 101 and front end interfaces 108 may comprise multiple components or circuits that are coupled together.

**[0269]** Front-end interfaces 108 may be implemented using transimpedance amplifiers that are coupled to analog to digital converters in a sigma delta converter. In some embodiments, a programmable gain amplifier (PGA) can be used in combination with the transimpedance-based front-ends. For example, the output of a transimpedance-based front-end may be output to a sigma-delta ADC that comprises a PGA. A PGA may be useful in order to provide another level of amplification and control of the stream of signals from detectors 106. The PGA may be an integrated circuit or built from a set of micro-relays. Alternatively, the PGA and ADC components in converter 900 may be integrated with the transimpedance-based front-end in sensor 101.

**[0270]** Due to the low-noise requirements for measuring blood analytes like glucose and the challenge of using multiple photodiodes in detector 106, the applicants developed a noise model to assist in configuring front-end 108. Conventionally, those skilled in the art have focused on optimizing the impedance of the transimpedance amplifiers to minimize noise.

**[0271]** However, the following noise model was discovered by the applicants:

$$Noise = \sqrt{aR + bR^2}, \text{ where:}$$

**[0272]**  $aR$  is characteristic of the impedance of the transimpedance amplifier; and

**[0273]**  $bR^2$  is characteristic of the impedance of the photodiodes in detector and the number of photodiodes in detector 106.

**[0274]** The foregoing noise model was found to be helpful at least in part due to the high SNR required to measure analytes like glucose. However, the foregoing noise model was not previously recognized by artisans at least in part because, in conventional devices, the major contributor to noise was generally believed to originate from the emitter or the LEDs. Therefore, artisans have generally continued to focus on reducing noise at the emitter.

**[0275]** However, for analytes like glucose, the discovered noise model revealed that one of the major contributors to noise was generated by the photodiodes. In addition, the amount of noise varied based on the number of photodiodes coupled to a transimpedance amplifier. Accordingly, combinations of various photodiodes from different manufacturers, different impedance values with the transimpedance amplifiers, and different numbers of photodiodes were tested as possible embodiments.

**[0276]** In some embodiments, different combinations of transimpedance to photodiodes may be used. For example, detectors 1-4 (as shown, e.g., in **FIGURE 12A**) may each comprise four photodiodes. In some embodiments, each detector of four photodiodes may be coupled to one or more transimpedance amplifiers. The configuration of these amplifiers may be set according to the model shown in **FIGURE 15J**.

**[0277]** Alternatively, each of the photodiodes may be coupled to its own respective transimpedance amplifier. For example, transimpedance amplifiers may be implemented as integrated circuits on the same circuit board as detectors 1-4. In this embodiment, the transimpedance amplifiers may be grouped into an averaging (or summing) circuit, which are known to those skilled in the art, in order to provide an output stream from the detector. The use of a summing amplifier to combine outputs from several transimpedance amplifiers into a single, analog signal may be helpful in improving the SNR relative to what is obtainable from a single transimpedance amplifier. The configuration of the transimpedance amplifiers in this setting may also be set according to the model shown in **FIGURE 15J**.

**[0278]** As yet another alternative, as noted above with respect to **FIGURES 12E** through **12H**, the photodiodes in detectors 106 may comprise multiple active areas that are grouped together. In some embodiments, each of these active areas may be provided its own respective transimpedance. This form of pairing may allow a transimpedance amplifier to be better matched to the characteristics of its corresponding photodiode or active area of a photodiode.

**[0279]** As noted, **FIGURE 15J** illustrates an exemplary noise model that may be useful in configuring transimpedance amplifiers. As shown, for a given

number of photodiodes and a desired SNR, an optimal impedance value for a transimpedance amplifier could be determined.

**[0280]** For example, an exemplary “4 PD per stream” sensor 1502 is shown where detector 106 comprises four photodiodes 1502. The photodiodes 1502 are coupled to a single transimpedance amplifier 1504 to produce an output stream 1506. In this example, the transimpedance amplifier comprises 10 M $\Omega$  resistors 1508 and 1510. Thus, output stream 1506 is produced from the four photodiodes (PD) 1502. As shown in the graph of **FIGURE 15J**, the model indicates that resistance values of about 10 M $\Omega$  may provide an acceptable SNR for analytes like glucose.

**[0281]** However, as a comparison, an exemplary “1 PD per stream” sensor 1512 is also shown in **FIGURE 15J**. In particular, sensor 1512 may comprise a plurality of detectors 106 that each comprises a single photodiode 1514. In addition, as shown for this example configuration, each of photodiodes 1514 may be coupled to respective transimpedance amplifiers 1516, e.g., 1 PD per stream. Transimpedance amplifiers are shown having 40 M $\Omega$  resistors 1518. As also shown in the graph of **FIGURE 15J**, the model illustrates that resistance values of 40 M $\Omega$  for resistors 1518 may serve as an alternative to the 4 photodiode per stream architecture of sensor 1502 described above and yet still provide an equivalent SNR.

**[0282]** Moreover, the discovered noise model also indicates that utilizing a 1 photodiode per stream architecture like that in sensor 1512 may provide enhanced performance because each of transimpedance amplifiers 1516 can be tuned or optimized to its respective photodiodes 1518. In some embodiments, an averaging component 1520 may also be used to help cancel or reduce noise across photodiodes 1518.

**[0283]** For purposes of illustration, **FIGURE 15K** shows different architectures (e.g., four PD per stream and one PD per stream) for various embodiments of a sensor and how components of the sensor may be laid out on a circuit board or substrate. For example, sensor 1522 may comprise a “4 PD per stream” architecture on a submount 700 in which each detector 106 comprises four

(4) photodiodes 1524. As shown for sensor 1522, the output of each set of four photodiodes 1524 is then aggregated into a single transimpedance amplifier 1526 to produce a signal.

**[0284]** As another example, a sensor 1528 may comprise a “1 PD per stream” architecture on submount 700 in which each detector 106 comprises four (4) photodiodes 1530. In sensor 1528, each individual photodiode 1530 is coupled to a respective transimpedance amplifier 1532. The output of the amplifiers 1532 may then be aggregated into averaging circuit 1520 to produce a signal.

**[0285]** As noted previously, one skilled in the art will recognize that the photodiodes and detectors may be arranged in different fashions to optimize the detected light. For example, sensor 1534 illustrates an exemplary “4 PD per stream” sensor in which the detectors 106 comprise photodiodes 1536 arranged in a linear fashion. Likewise, sensor 1538 illustrates an exemplary “1 PD per stream” sensor in which the detectors comprise photodiodes 1540 arranged in a linear fashion.

**[0286]** Alternatively, sensor 1542 illustrates an exemplary “4 PD per stream” sensor in which the detectors 106 comprise photodiodes 1544 arranged in a two-dimensional pattern, such as a zig-zag pattern. Sensor 1546 illustrates an exemplary “1 PD per stream” sensor in which the detectors comprise photodiodes 1548 also arranged in a zig-zag pattern.

**[0287]** **FIGURE 15L** illustrates an exemplary architecture for a switched-capacitor-based front-end. As shown, front-end interfaces 108 may be implemented using switched capacitor circuits and any number of front-end interfaces 108 may be implemented. The output of these switched capacitor circuits may then be provided to a digital interface 1000 and signal processor 110. Switched capacitor circuits may be useful in system 100 for their resistor free design and analog averaging properties. In particular, the switched capacitor circuitry provides for analog averaging of the signal that allows for a lower smaller sampling rate (e.g., 2 KHz sampling for analog versus 48 KHz sampling for digital designs) than similar digital designs. In some embodiments, the switched capacitor architecture in front end interfaces 108 may provide a similar or equivalent SNR to other front end designs,

such as a sigma delta architecture. In addition, a switched capacitor design in front end interfaces 108 may require less computational power by signal processor 110 to perform the same amount of decimation to obtain the same SNR.

**[0288] FIGURES 16A and 16B** illustrate embodiments of disposable optical sensors 1600. In an embodiment, any of the features described above, such as protrusion, shielding, and/or heat sink features, can be incorporated into the disposable sensors 1600 shown. For instance, the sensors 1600 can be used as the sensors 101 in the system 100 described above with respect to FIGURE 1. Moreover, any of the features described above, such as protrusion, shielding, and/or heat sink features, can be implemented in other disposable sensor designs that are not depicted herein.

**[0289]** The sensors 1600 include an adult/pediatric sensor 1610 for finger placement and a disposable infant/neonate sensor 1602 configured for toe, foot or hand placement. Each sensor 1600 has a tape end 1610 and an opposite connector end 1620 electrically and mechanically interconnected via a flexible coupling 1630. The tape end 1610 attaches an emitter and detector to a tissue site. Although not shown, the tape end 1610 can also include any of the protrusion, shielding, and/or heat sink features described above. The emitter illuminates the tissue site and the detector generates a sensor signal responsive to the light after tissue absorption, such as absorption by pulsatile arterial blood flow within the tissue site.

**[0290]** The sensor signal is communicated via the flexible coupling 1630 to the connector end 1620. The connector end 1620 can mate with a cable (not shown) that communicates the sensor signal to a monitor (not shown), such as any of the cables or monitors shown above with respect to FIGURES 2A through 2D. Alternatively, the connector end 1620 can mate directly with the monitor.

**[0291] FIGURE 17** illustrates an exploded view of certain of the components of the sensor 301f described above. A heat sink 1751 and a cable 1781 attach to an emitter shell 1704. The emitter shell attaches to a flap housing 1707. The flap housing 1707 includes a receptacle 1709 to receive a cylindrical

housing 1480/1580 (not shown) attached to an emitter submount 1702, which is attached to a circuit board 1719.

**[0292]** A spring 1787 attaches to a detector shell 1706 via pins 1783, 1785, which hold the emitter and detector shells 1704, 1706 together. A support structure 1791 attaches to the detector shell 1706, which provides support for a shielding enclosure 1790. A noise shield 1713 attaches to the shielding enclosure 1790. A detector submount 1700 is disposed inside the shielding enclosure 1790. A finger bed 1710 provides a surface for placement of the patient's finger. Finger bed 1710 may comprise a gripping surface or gripping features, which may assist in placing and stabilizing a patient's finger in the sensor. A partially cylindrical protrusion 1705 may also be disposed in the finger bed 1710. As shown, finger bed 1710 attaches to the noise shield 1703. The noise shield 1703 may be configured to reduce noise, such as from ambient light and electromagnetic noise. For example, the noise shield 1703 may be constructed from materials having an opaque color, such as black or a dark blue, to prevent light piping.

**[0293]** Noise shield 1703 may also comprise a thermistor 1712. The thermistor 1712 may be helpful in measuring the temperature of a patient's finger. For example, the thermistor 1712 may be useful in detecting when the patient's finger is reaching an unsafe temperature that is too hot or too cold. In addition, the temperature of the patient's finger may be useful in indicating to the sensor the presence of low perfusion as the temperature drops. In addition, the thermistor 1712 may be useful in detecting a shift in the characteristics of the water spectrum in the patient's finger, which can be temperature dependent.

**[0294]** Moreover, a flex circuit cover 1706 attaches to the pins 1783, 1785. Although not shown, a flex circuit can also be provided that connects the circuit board 1719 with the submount 1700 (or a circuit board to which the submount 1700 is connected). A flex circuit protector 1760 may be provided to provide a barrier or shield to the flex circuit (not shown). In particular, the flex circuit protector 1760 may also prevent any electrostatic discharge to or from the flex circuit. The flex circuit protector 1760 may be constructed from well known materials, such as a plastic or rubber materials.

**[0295]** **FIGURE 18** shows the results obtained by an exemplary sensor 101 of the present disclosure that was configured for measuring glucose. This sensor 101 was tested using a pure water ex-vivo sample. In particular, ten samples were prepared that ranged from 0-55 mg/dL. Two samples were used as a training set and eight samples were then used as a test population. As shown, embodiments of the sensor 101 were able to obtain at least a standard deviation of 13 mg/dL in the training set and 11 mg/dL in the test population.

**[0296]** **FIGURE 19** shows the results obtained by an exemplary sensor 101 of the present disclosure that was configured for measuring glucose. This sensor 101 was tested using a turbid ex-vivo sample. In particular, 25 samples of water/glucose/Lyposin were prepared that ranged from 0-55 mg/dL. Five samples were used as a training set and 20 samples were then used as a test population. As shown, embodiments of sensor 101 were able to obtain at least a standard deviation of 37 mg/dL in the training set and 32 mg/dL in the test population.

**[0297]** **FIGURES 20 through 22** shows other results that can be obtained by an embodiment of system 100. In **FIGURE 20**, 150 blood samples from two diabetic adult volunteers were collected over a 10-day period. Invasive measurements were taken with a YSI glucometer to serve as a reference measurement. Noninvasive measurements were then taken with an embodiment of system 100 that comprised four LEDs and four independent detector streams. As shown, the system 100 obtained a correlation of about 85% and Arms of about 31 mg/dL.

**[0298]** In **FIGURE 21**, 34 blood samples were taken from a diabetic adult volunteer collected over a 2-day period. Invasive measurements were also taken with a glucometer for comparison. Noninvasive measurements were then taken with an embodiment of system 100 that comprised four LEDs in emitter 104 and four independent detector streams from detectors 106. As shown, the system 100 was able to attain a correlation of about 90% and Arms of about 22 mg/dL.

**[0299]** The results shown in **FIGURE 22** relate to total hemoglobin testing with an exemplary sensor 101 of the present disclosure. In particular, 47 blood samples were collected from nine adult volunteers. Invasive measurements were

then taken with a CO-oximeter for comparison. Noninvasive measurements were taken with an embodiment of system 100 that comprised four LEDs in emitter 104 and four independent detector channels from detectors 106. Measurements were averaged over 1 minute. As shown, the testing resulted in a correlation of about 93% and Arms of about 0.8 mg/dL.

**[0300]** Conditional language used herein, such as, among others, "can," "could," "might," "may," "e.g.," and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or states. Thus, such conditional language is not generally intended to imply that features, elements and/or states are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or states are included or are to be performed in any particular embodiment.

**[0301]** While certain embodiments of the inventions disclosed herein have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions disclosed herein. Indeed, the novel methods and systems described herein can be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein can be made without departing from the spirit of the inventions disclosed herein. The claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of certain of the inventions disclosed herein.



WHAT IS CLAIMED IS:

1. A noninvasive sensor capable of producing a signal responsive to light attenuated by tissue at a measurement site on a patient, the sensor comprising:
  - an optical source configured to emit optical radiation onto said tissue at said measurement site;
  - at least one photodetector configured to detect the optical radiation from said optical source after attenuation by said tissue of said patient and output at least one respective signal stream responsive to said detected optical radiation;
  - a housing positioning said optical source and said at least one photodetector with respect to said measurement site;
  - a thermistor operably associated with said housing and configured to output a temperature signal responsive to a temperature of said measurement site.
2. The sensor of claim 1, wherein said tissue at said measurement site comprises a digit of said patient.
3. The sensor of claim 1, wherein at least a portion of said housing is reusable.
4. The sensor of claim 1, wherein at least a portion of said housing is disposable.
5. The sensor of claim 1, comprising a cable connected to a patient monitor capable of processing the at least one signal stream and the temperature signal to determine output values for one or more physiological parameters.
6. The sensor of claim 5, wherein one of the one or more physiological parameters comprises total hemoglobin.
7. The sensor of claim 5, wherein the thermistor measures the temperature of said measurement site to correct wavelength drift from said optical source after attenuation by said tissue.
8. The sensor of claim 1, wherein the sensor comprises plurality of photodetectors configured to detect the optical radiation from said optical source

after attenuation by said tissue of said patient and each output a respective signal stream responsive to said detected optical radiation.

9. The sensor of claim 1, wherein said optical source is configured to emit optical radiation at least at wavelength between about 1600 nm and about 1700 nm.

10. A method of measuring an analyte and a temperature at a measurement site of a living patient, said method comprising:

electronically emitting optical radiation on the measurement site;

electronically detecting said optical radiation after attenuation by tissue at the measurement site;

electronically measuring the temperature of said measurement site;

using a signal processor, electronically correcting wavelength drift from said optical source after attenuation by tissue of said measurement site; and

electronically determining an output measurement value indicative of the analyte based on the detected streams of optical radiation.

11. The method of claim 9, wherein said tissue at said measurement site comprises a digit of said patient.

12. The method of claim 9, wherein the method further comprises electronically correcting wavelength drift after attenuation by said tissue.

13. The method of claim 9, wherein said analyte comprises total hemoglobin.

14. A signal processing system capable of producing a signal responsive to light attenuated by tissue at a measurement site on a patient, the system comprising:

a noninvasive optical sensor including:

an optical source configured to emit optical radiation onto said tissue at said measurement site;

at least one photodetector configured to detect the optical radiation from said optical source after attenuation by said tissue of said patient and output at least one respective signal stream responsive to said detected optical radiation;

a thermistor operably associated with said housing and configured to output a temperature signal responsive to a temperature of said measurement site.

a monitor capable of processing the at least one signal stream and the temperature sensor to determine output values for one or more physiological parameters; and

a cable connected to the monitor providing communication between said optical sensor and said monitor.

15. The system of claim 14, wherein said tissue at said measurement site comprises a digit of said patient.

16. The system of claim 14, wherein at least a portion of said sensor is reusable.

17. The system of claim 14, wherein at least a portion of said sensor is disposable.

18. The system of claim 14, wherein one of the one or more physiological parameters comprises total hemoglobin.

19. The system of claim 14, wherein the thermistor measures the temperature of said measurement site to correct wavelength drift from said optical source after attenuation by said tissue.

20. The system of claim 14, wherein the sensor comprises plurality of photodetectors configured to detect the optical radiation from said optical source after attenuation by said tissue of said patient and each output a respective signal stream responsive to said detected optical radiation.

21. The system of claim 14, wherein said optical source is configured to emit optical radiation at least at wavelength between about 1600 nm and about 1700 nm.

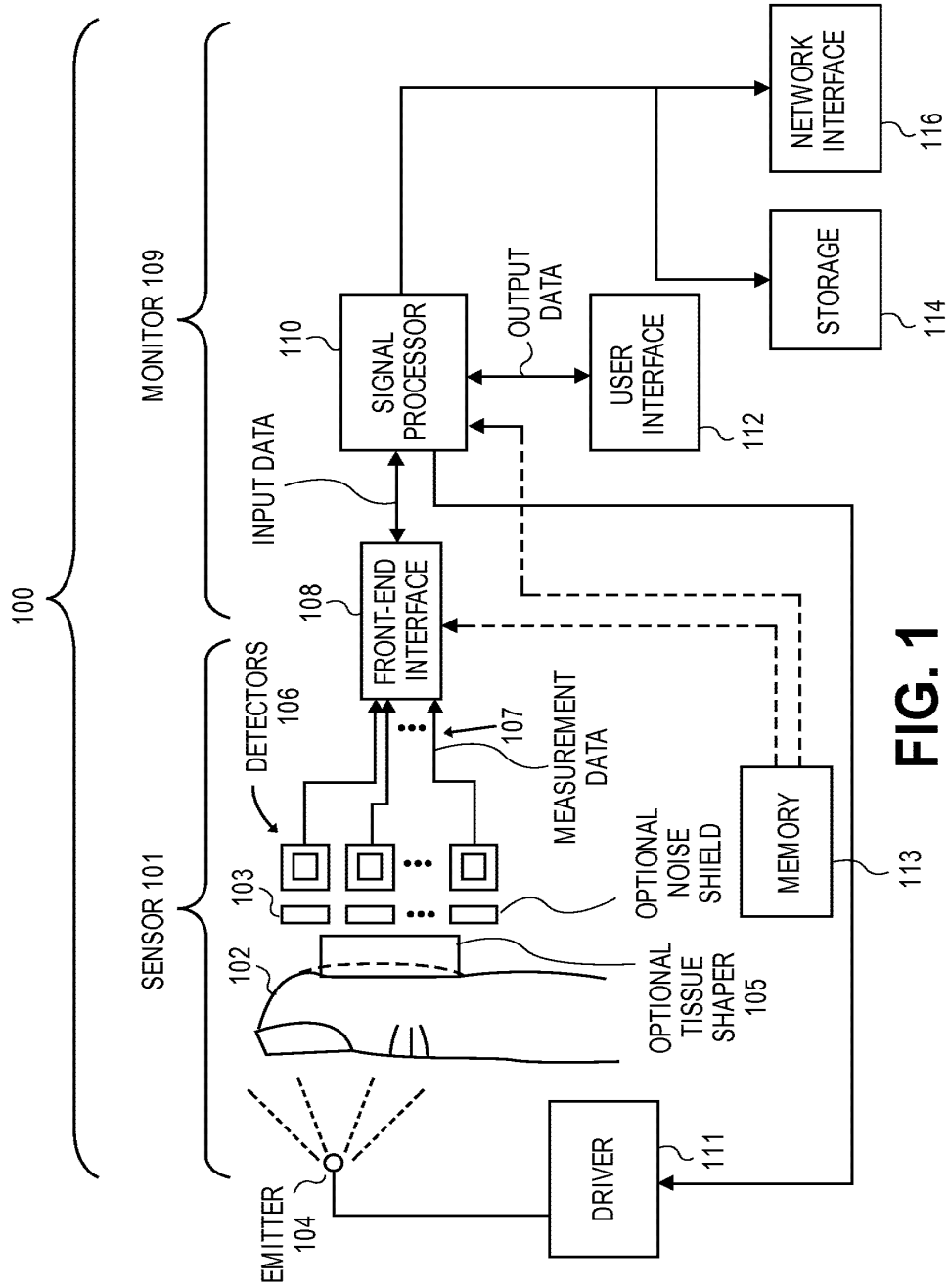
22. The system of claim 14, wherein said monitor comprises handheld monitor.

**MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE  
MEASUREMENT OF BLOOD CONSTITUENTS**

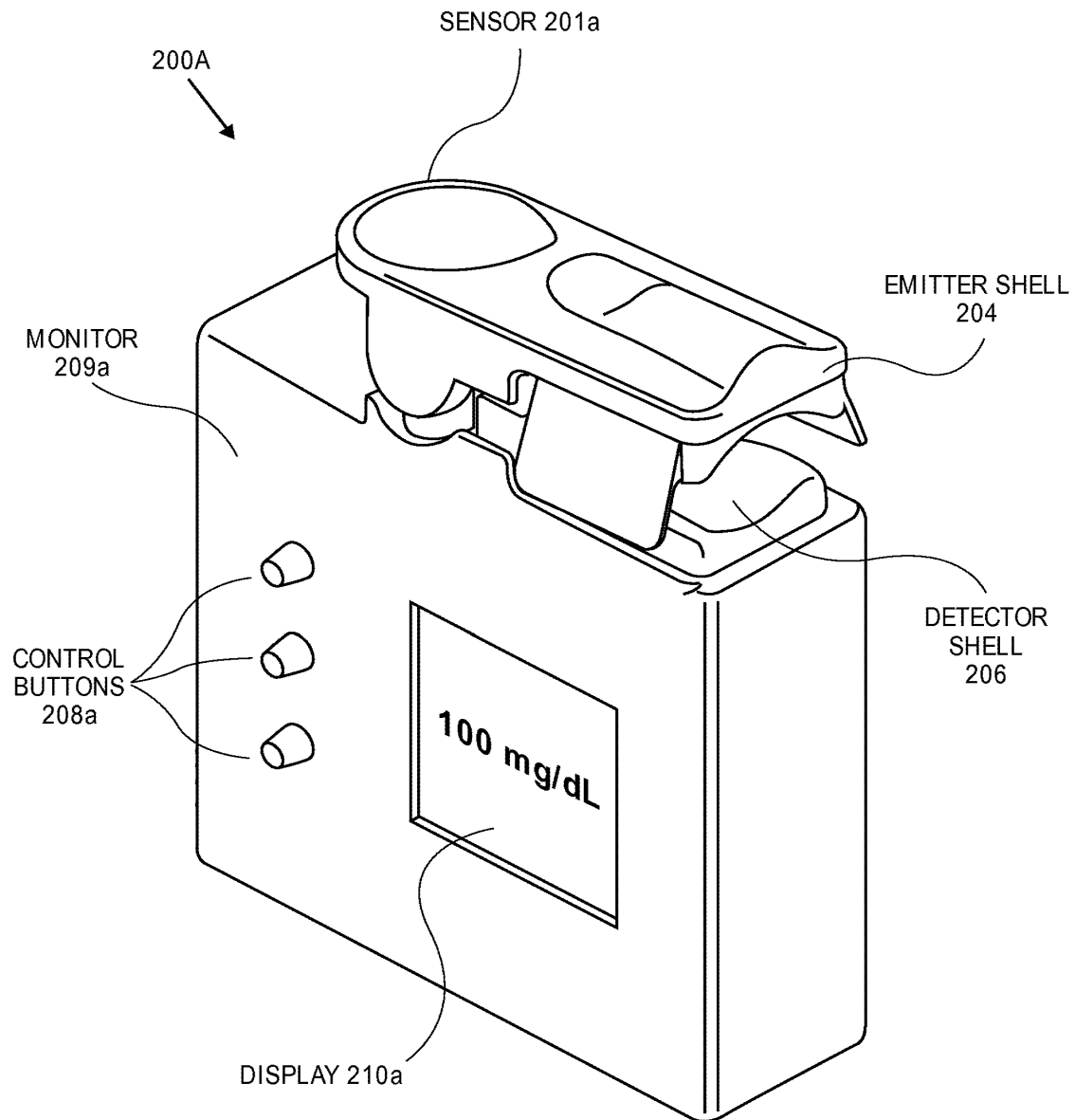
**ABSTRACT OF THE DISCLOSURE**

The present disclosure relates to noninvasive methods, devices, and systems for measuring various blood constituents or analytes, such as glucose. In an embodiment, a light source comprises LEDs and super-luminescent LEDs. The light source emits light at least wavelengths of about 1610 nm, about 1640 nm, and about 1665 nm. In an embodiment, the detector comprises a plurality of photodetectors arranged in a special geometry comprising one of a substantially linear substantially equal spaced geometry, a substantially linear substantially non-equal spaced geometry, and a substantially grid geometry.

9290680



2/65



**FIG. 2A**

3/65

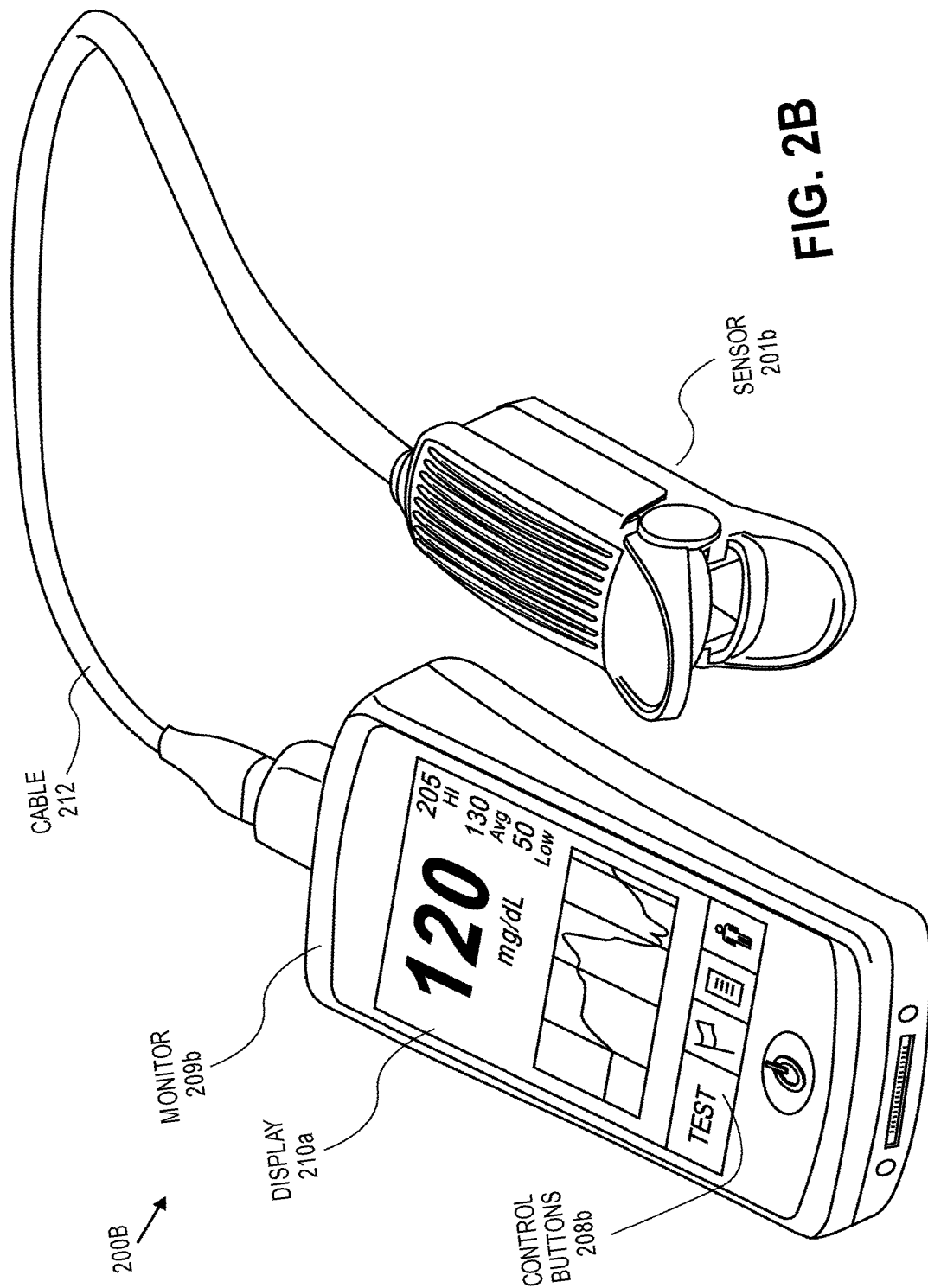
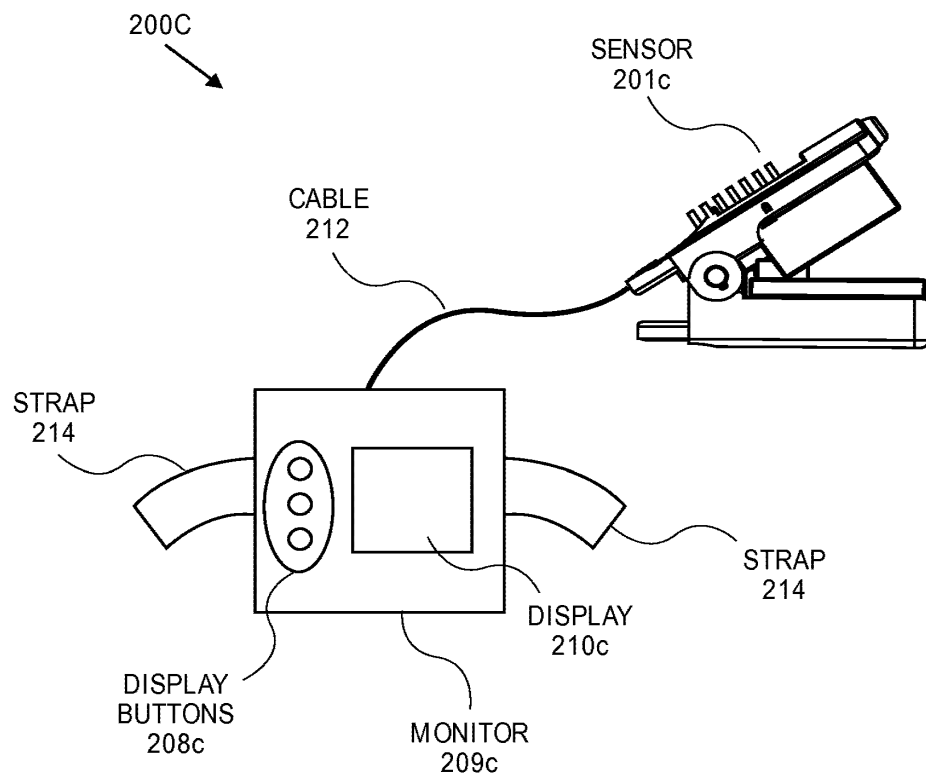


FIG. 2B

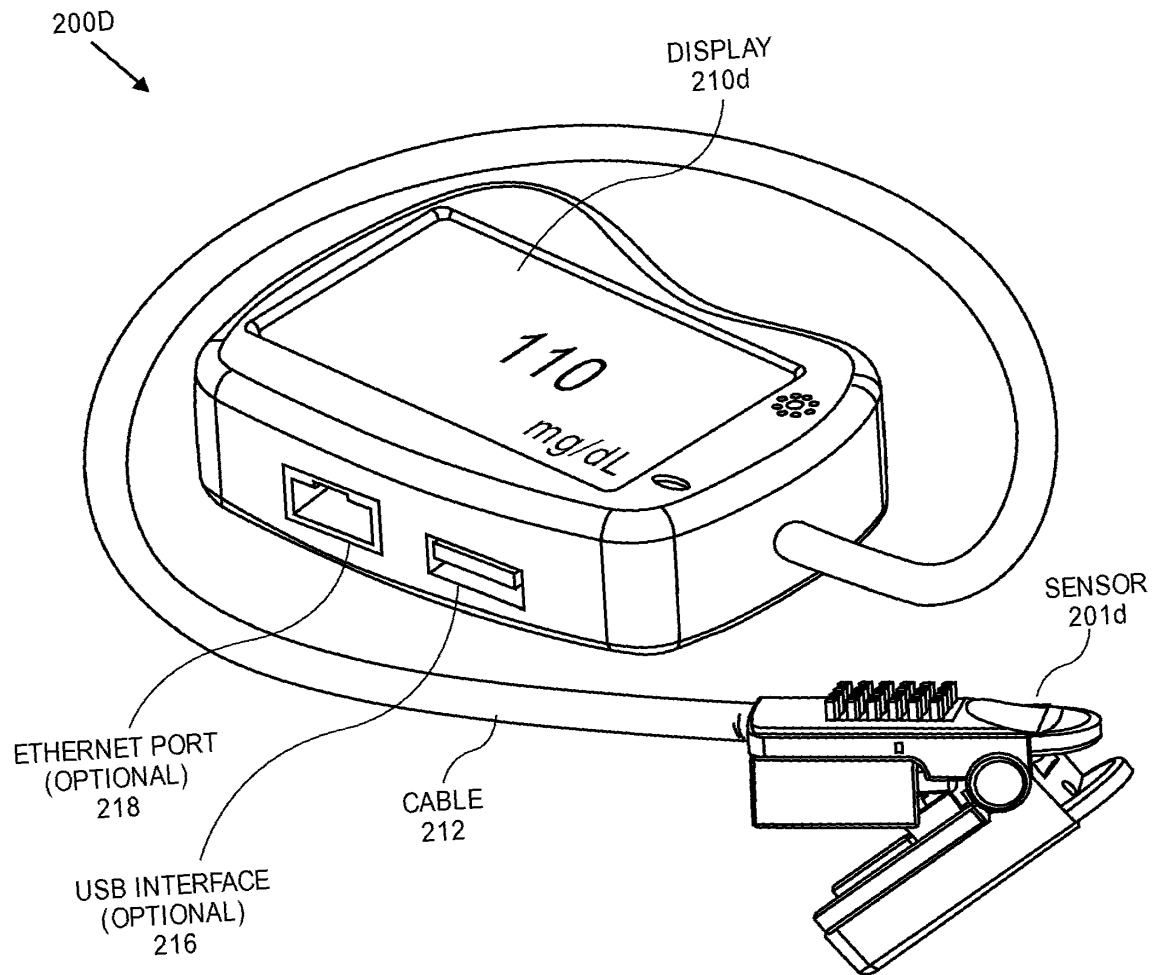
4/65



**FIG. 2C**

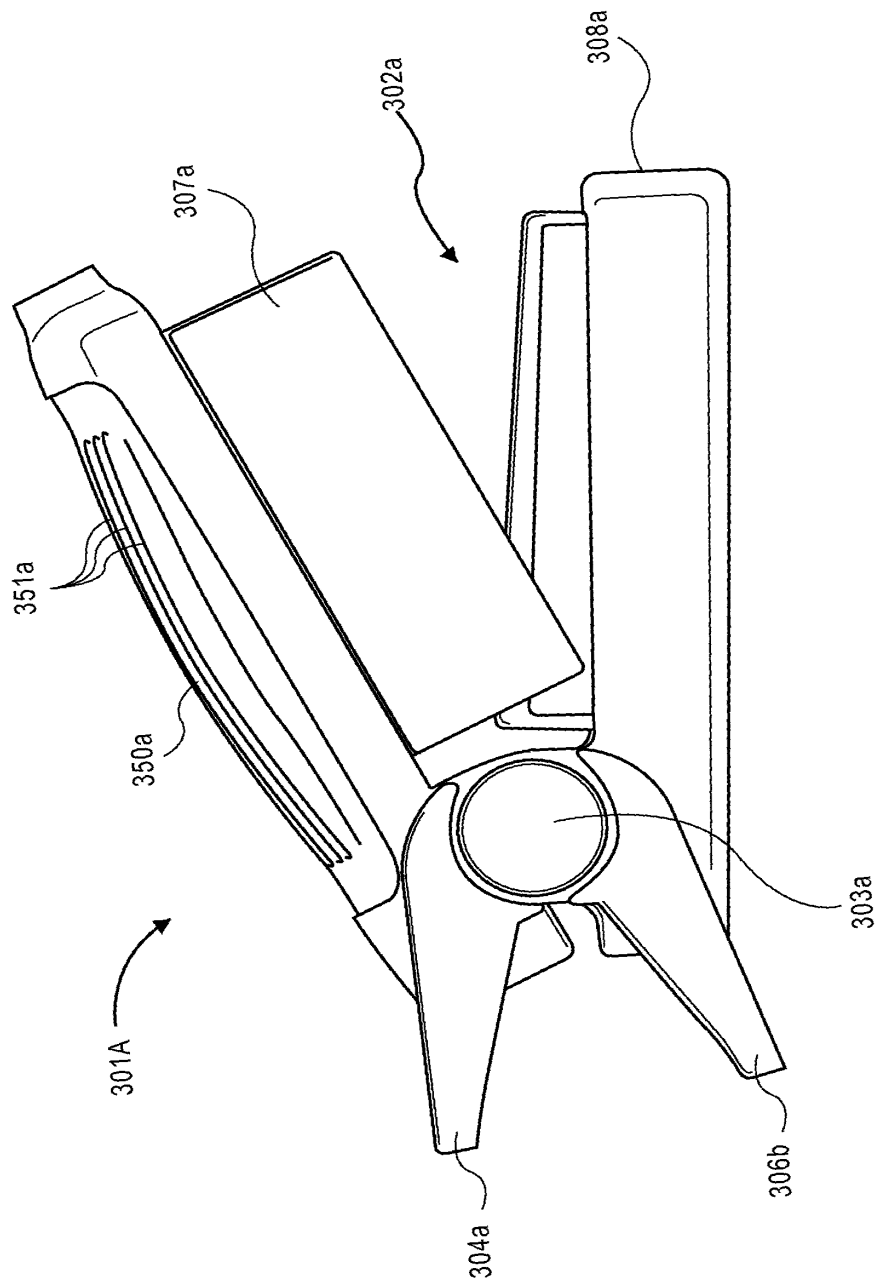


5/65



**FIG. 2D**

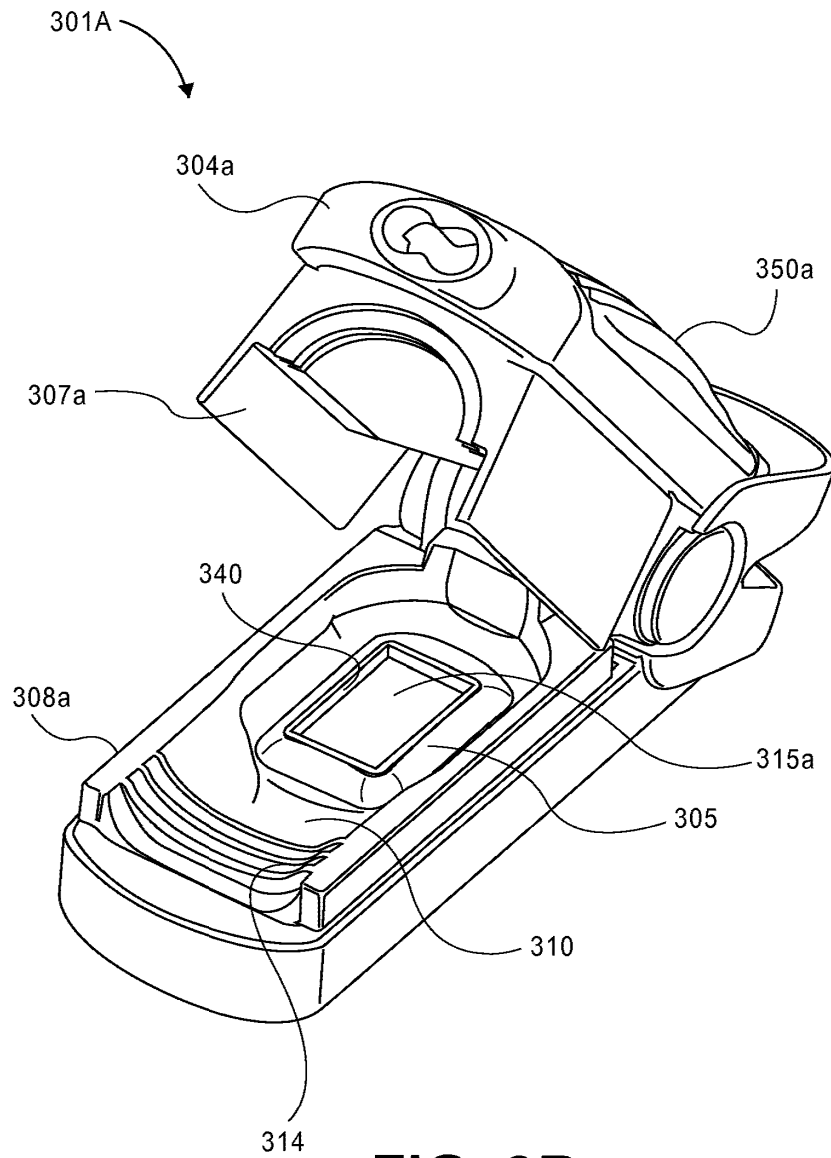
6/65



**FIG. 3A**

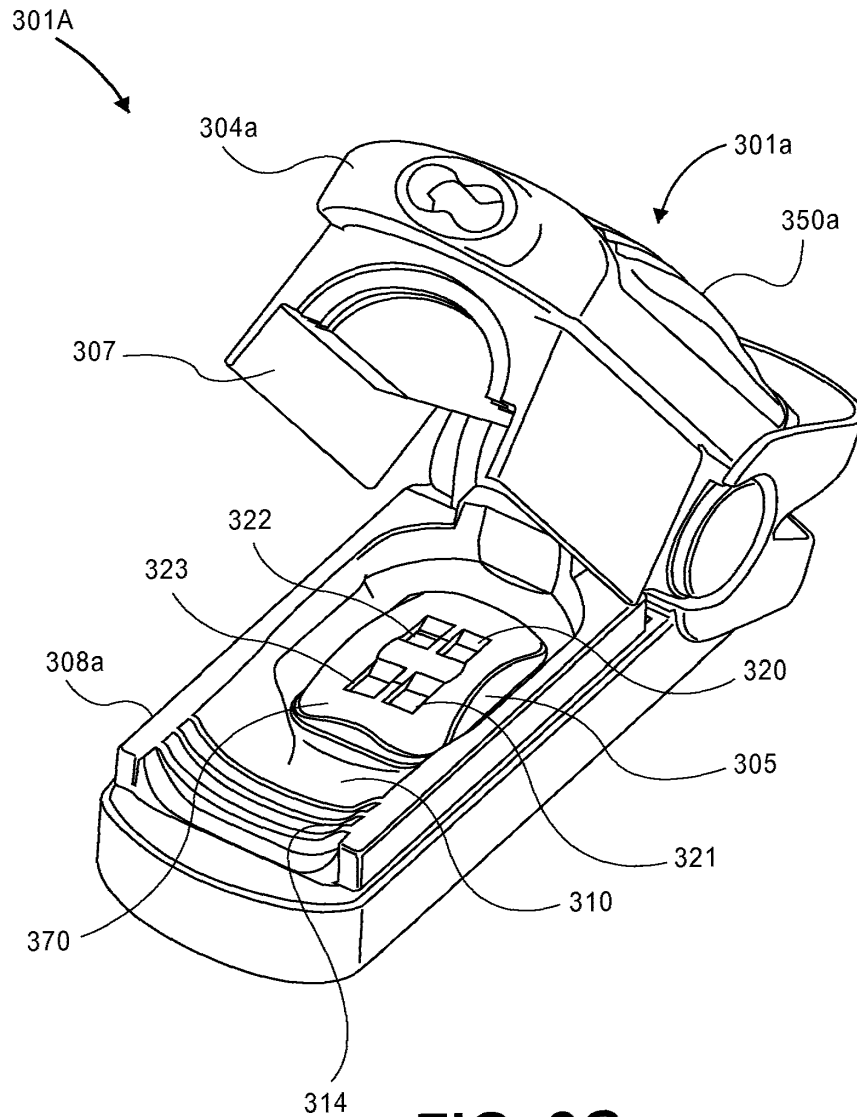
Appx59297

7/65



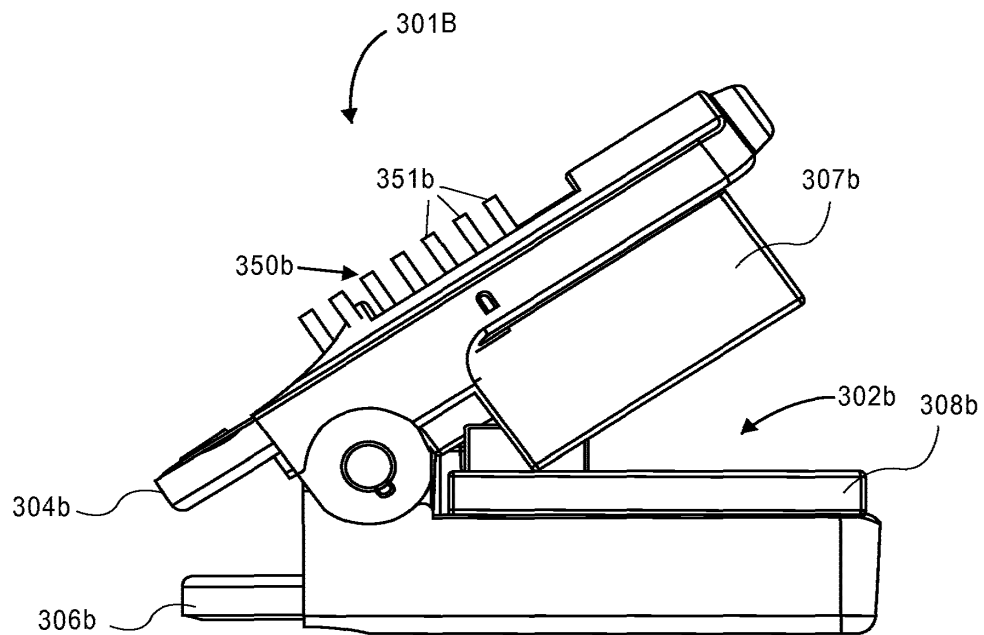
**FIG. 3B**

8/65



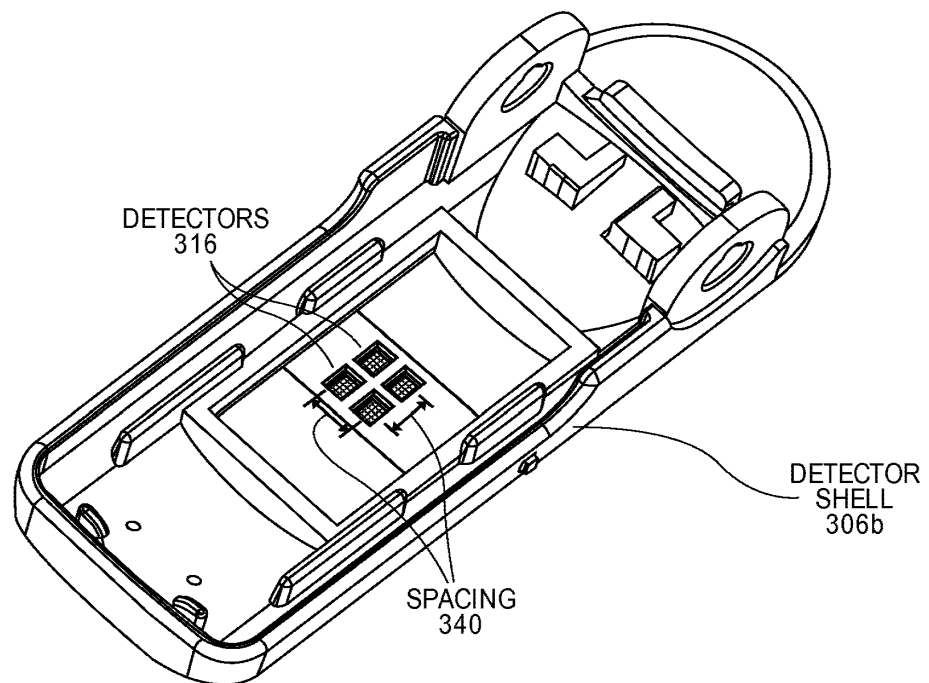
**FIG. 3C**

9/65



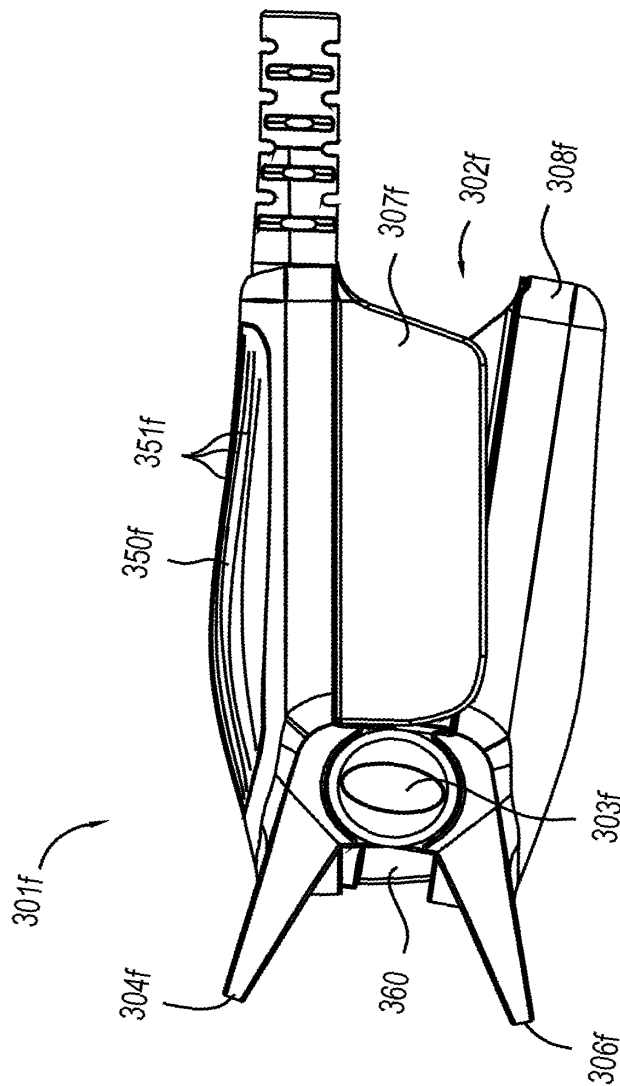
**FIG. 3D**

10/65

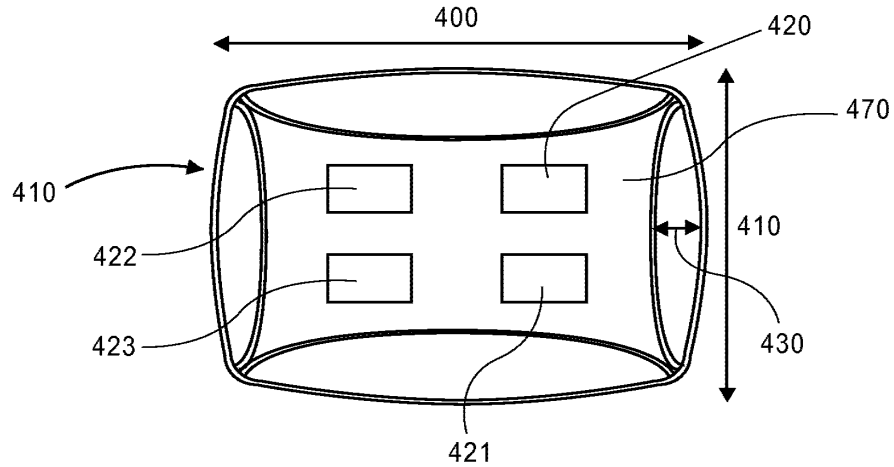


**FIG. 3E**

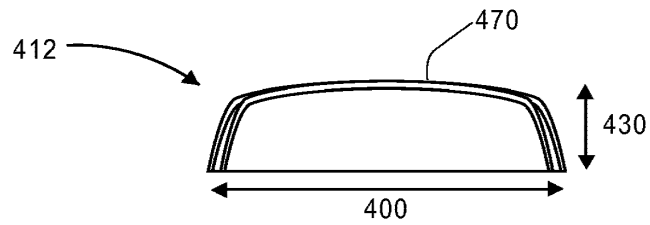
11/65



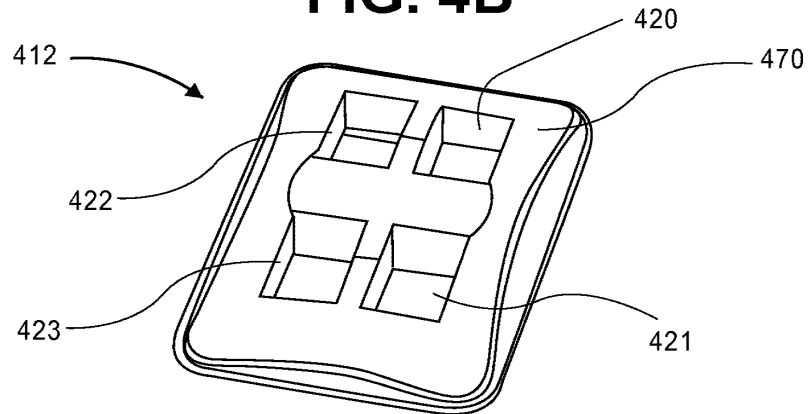
12/65



**FIG. 4A**



**FIG. 4B**



**FIG. 4C**



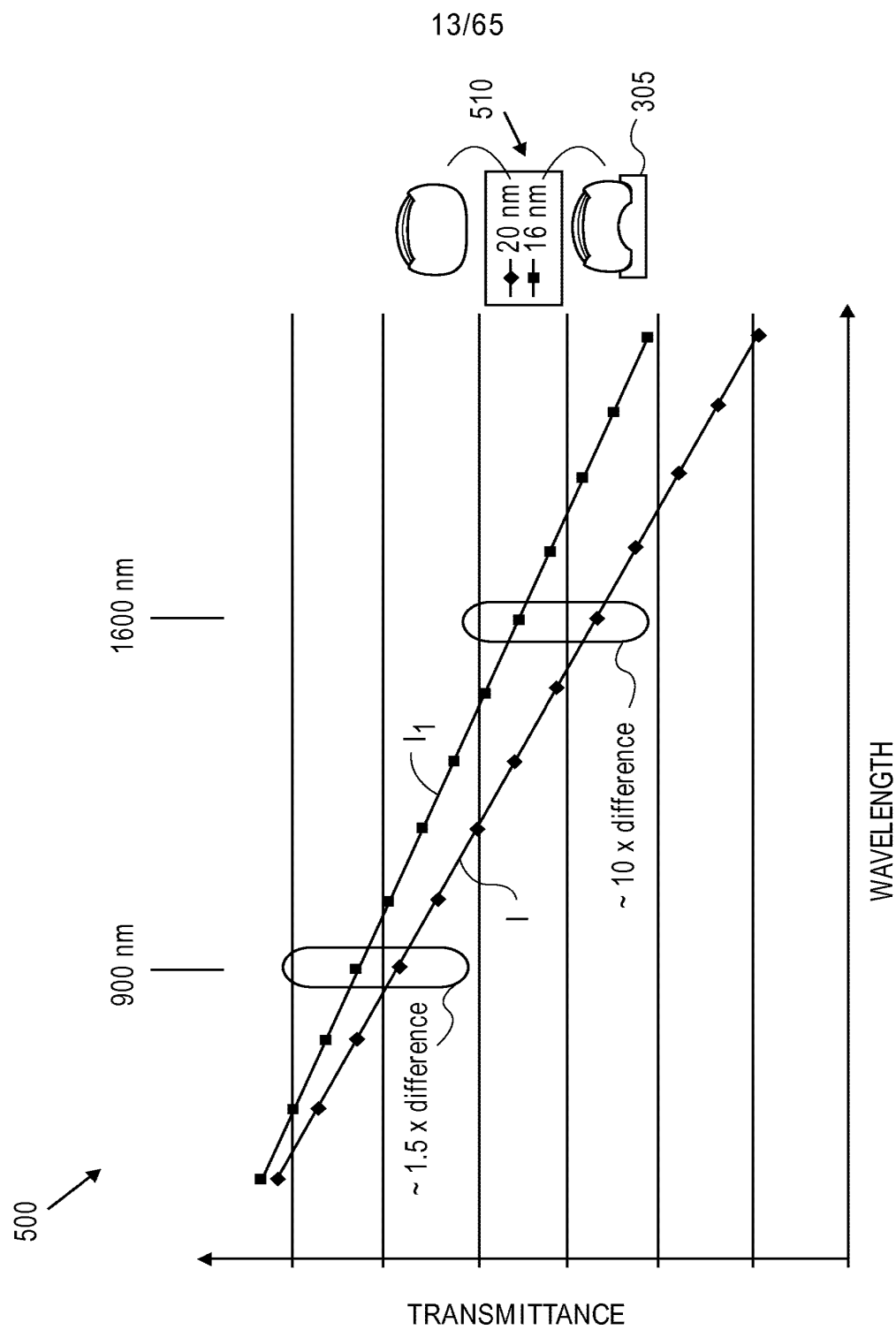
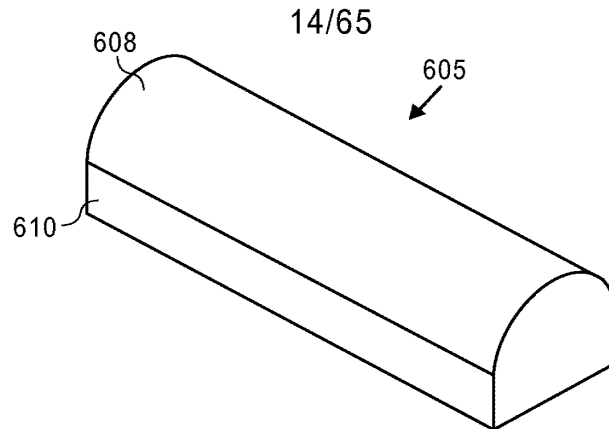
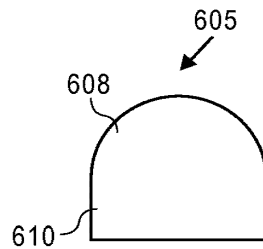


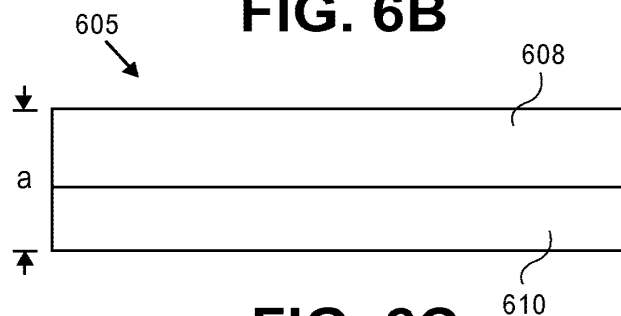
FIG. 5



**FIG. 6A**



**FIG. 6B**

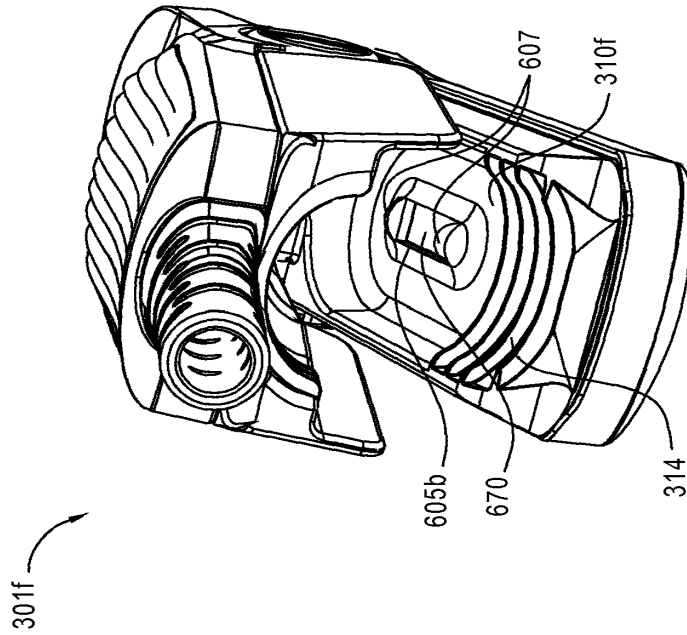


**FIG. 6C**



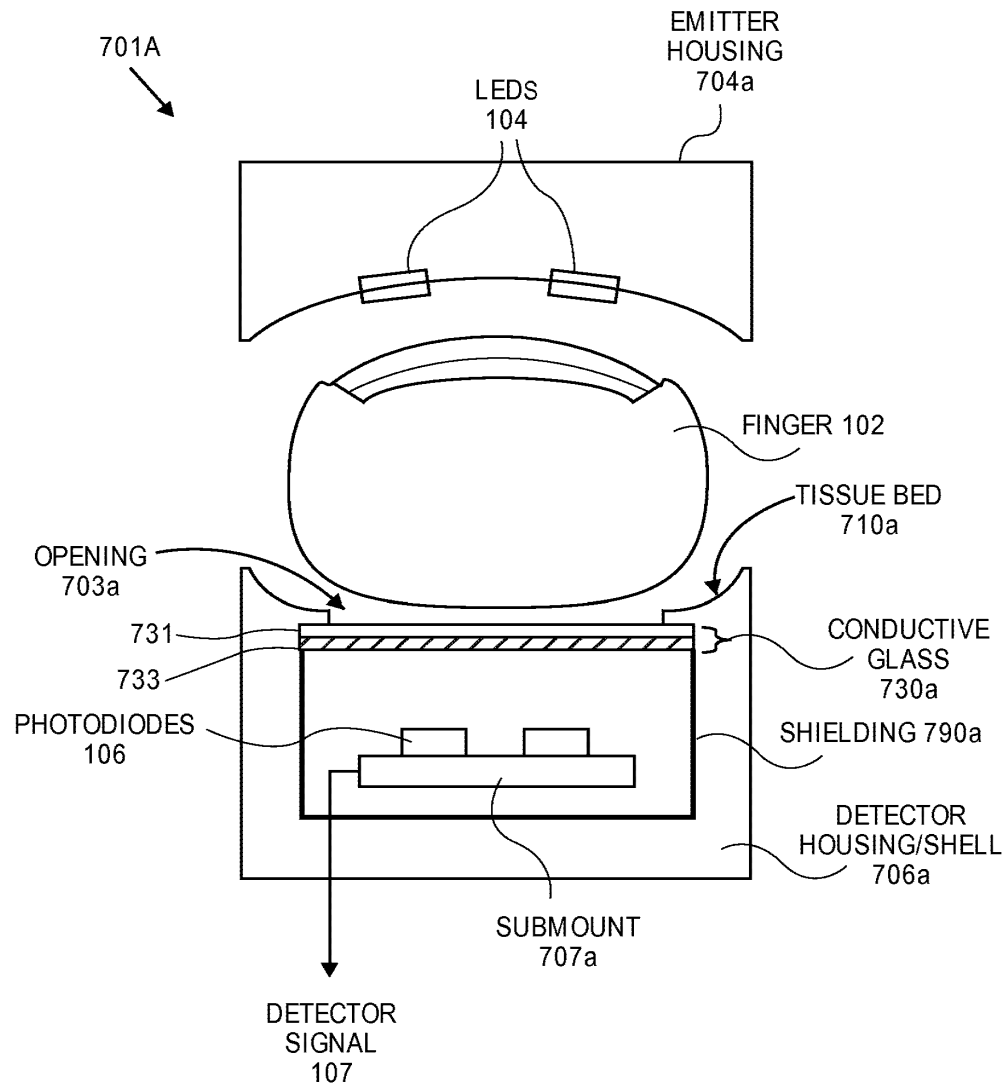
**FIG. 6D**

15/65

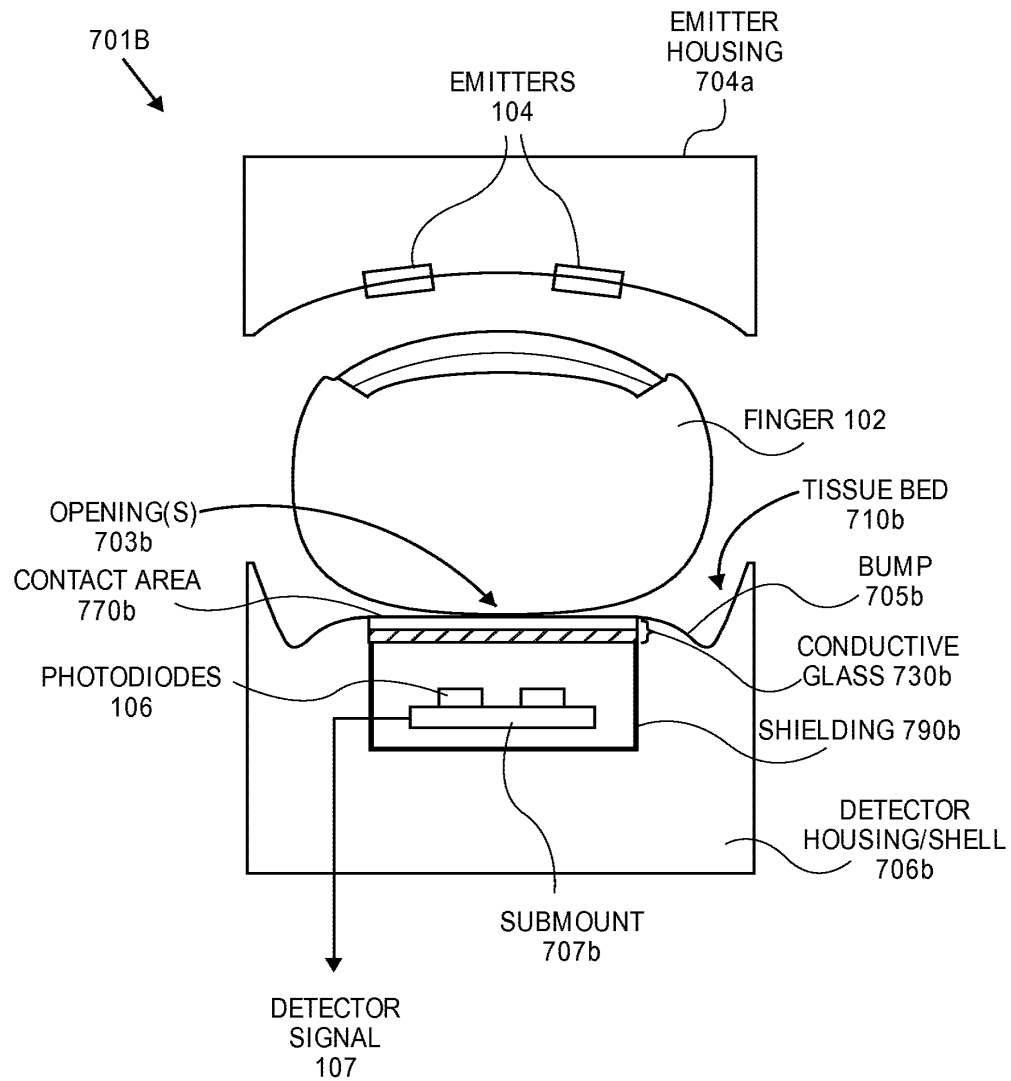


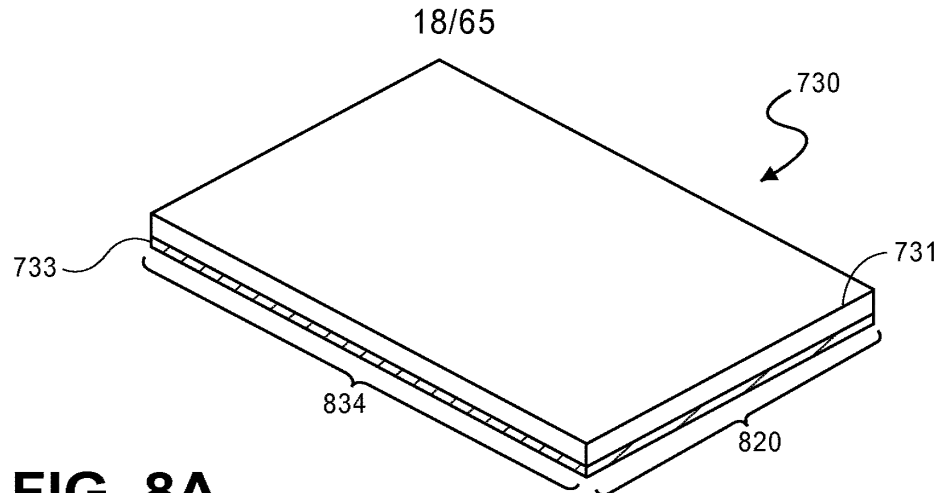
**FIG. 6E**

16/65

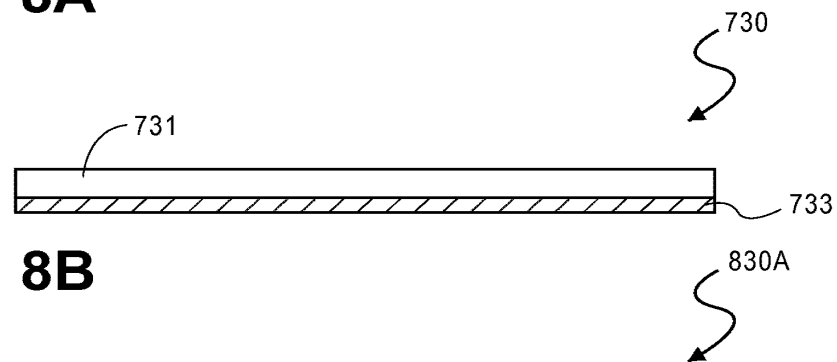
**FIG. 7A**

17/65

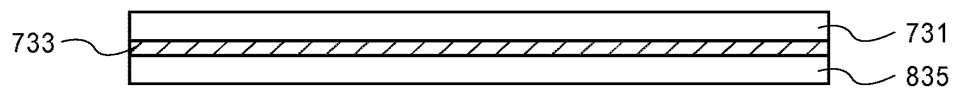
**FIG. 7B**



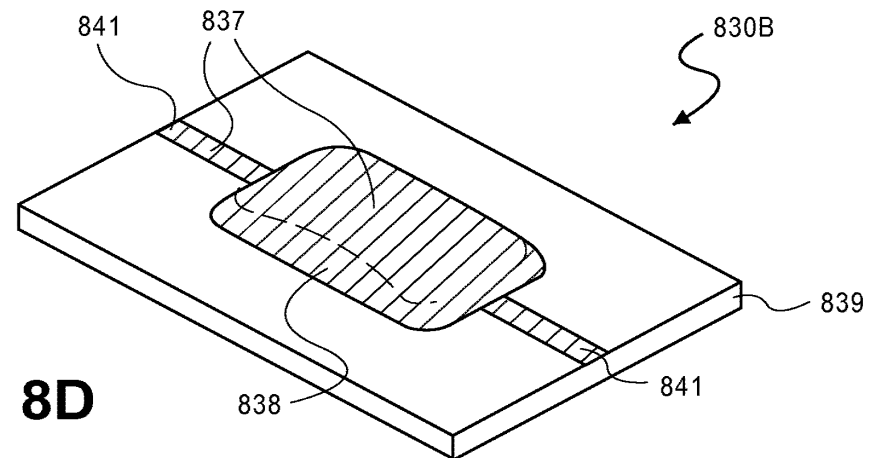
**FIG. 8A**



**FIG. 8B**



**FIG. 8C**



**FIG. 8D**

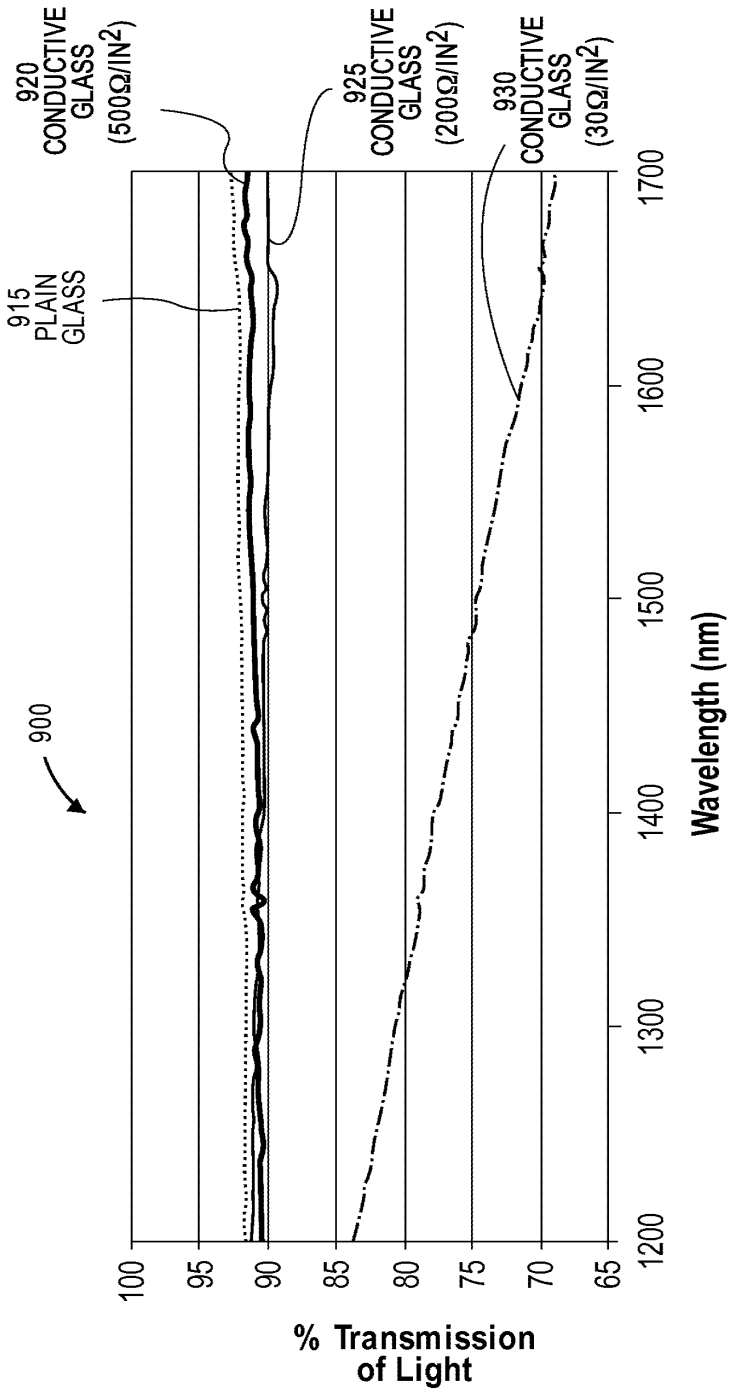
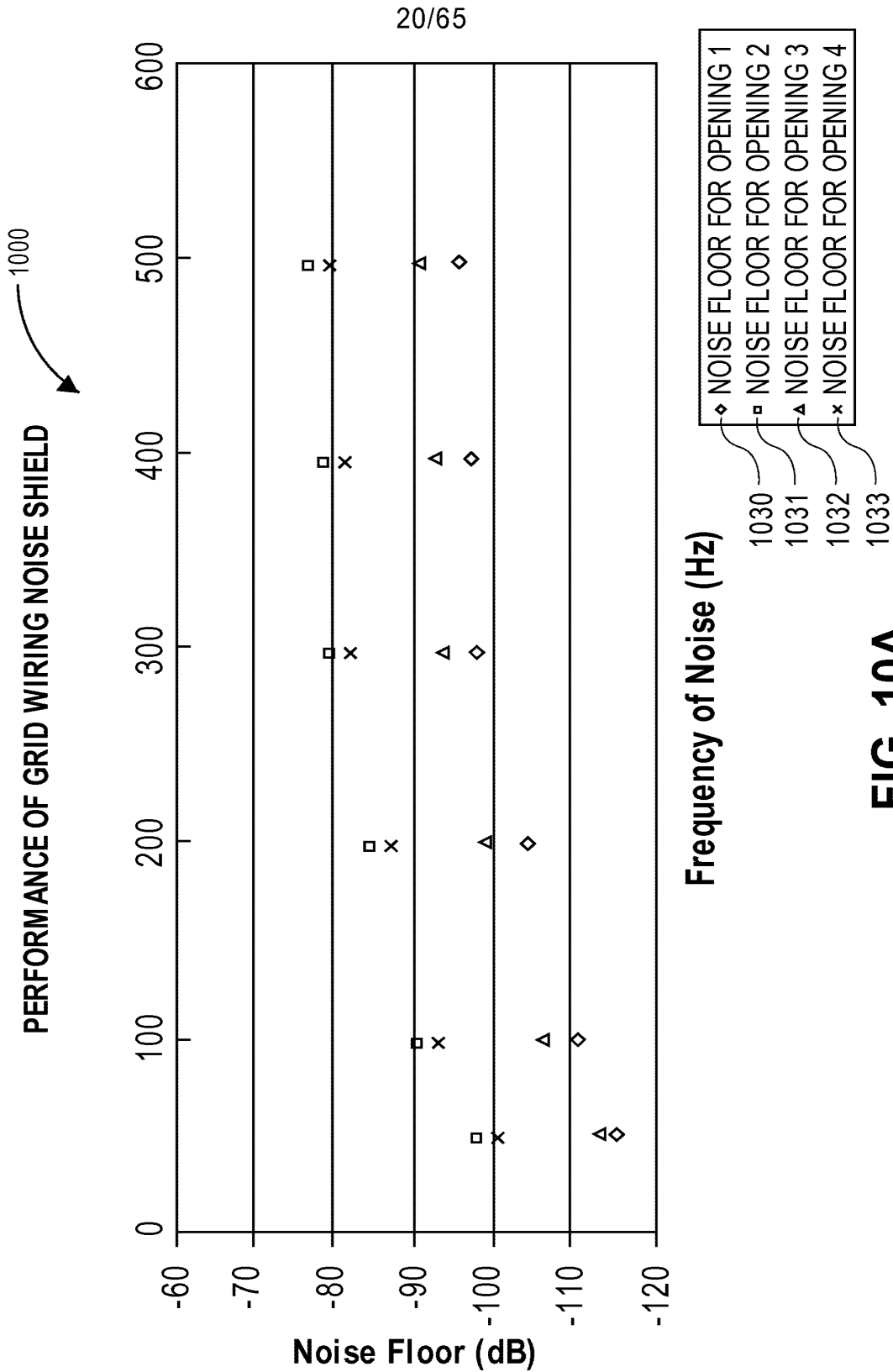
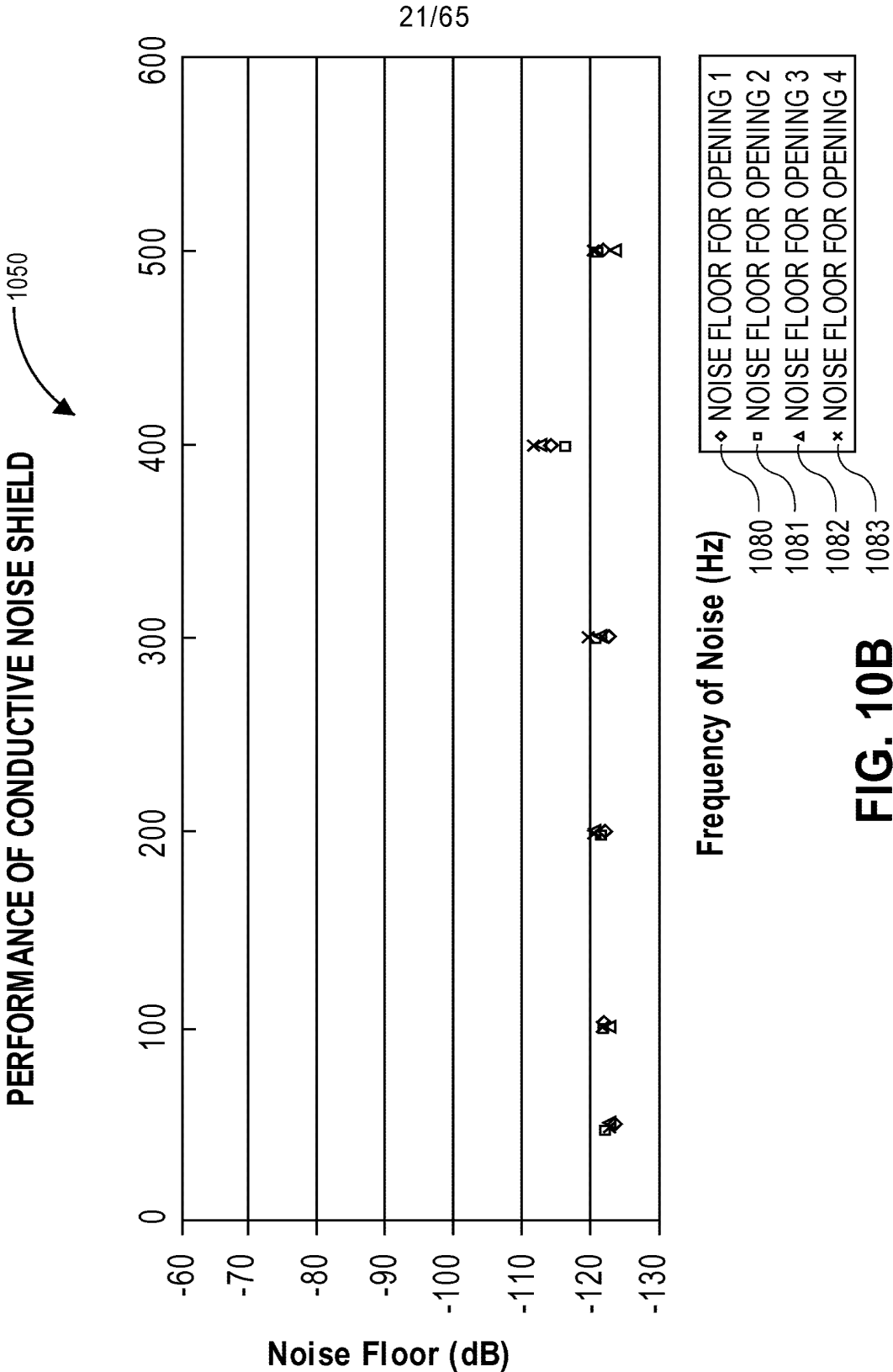


FIG. 9



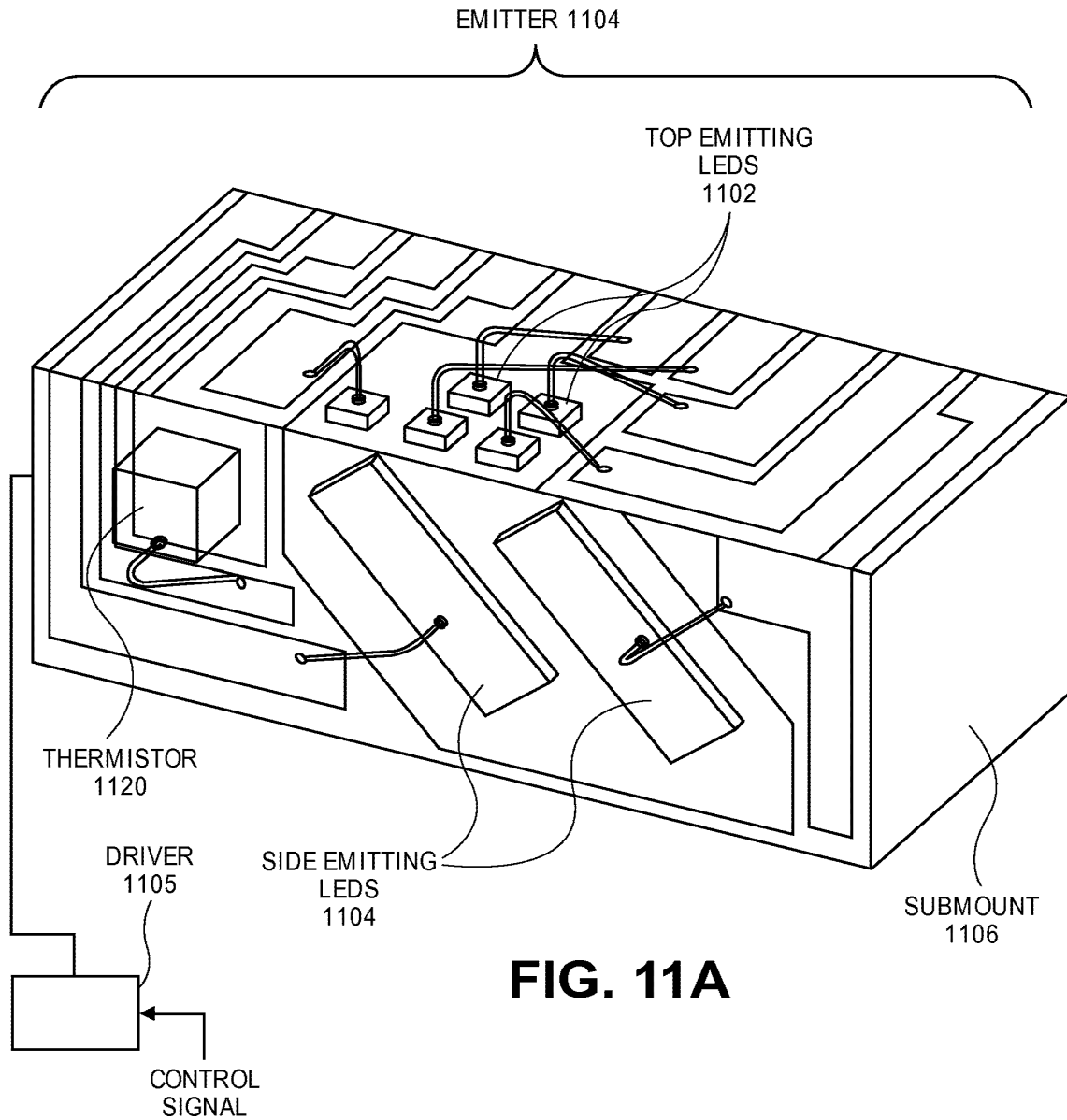
**FIG. 10A**



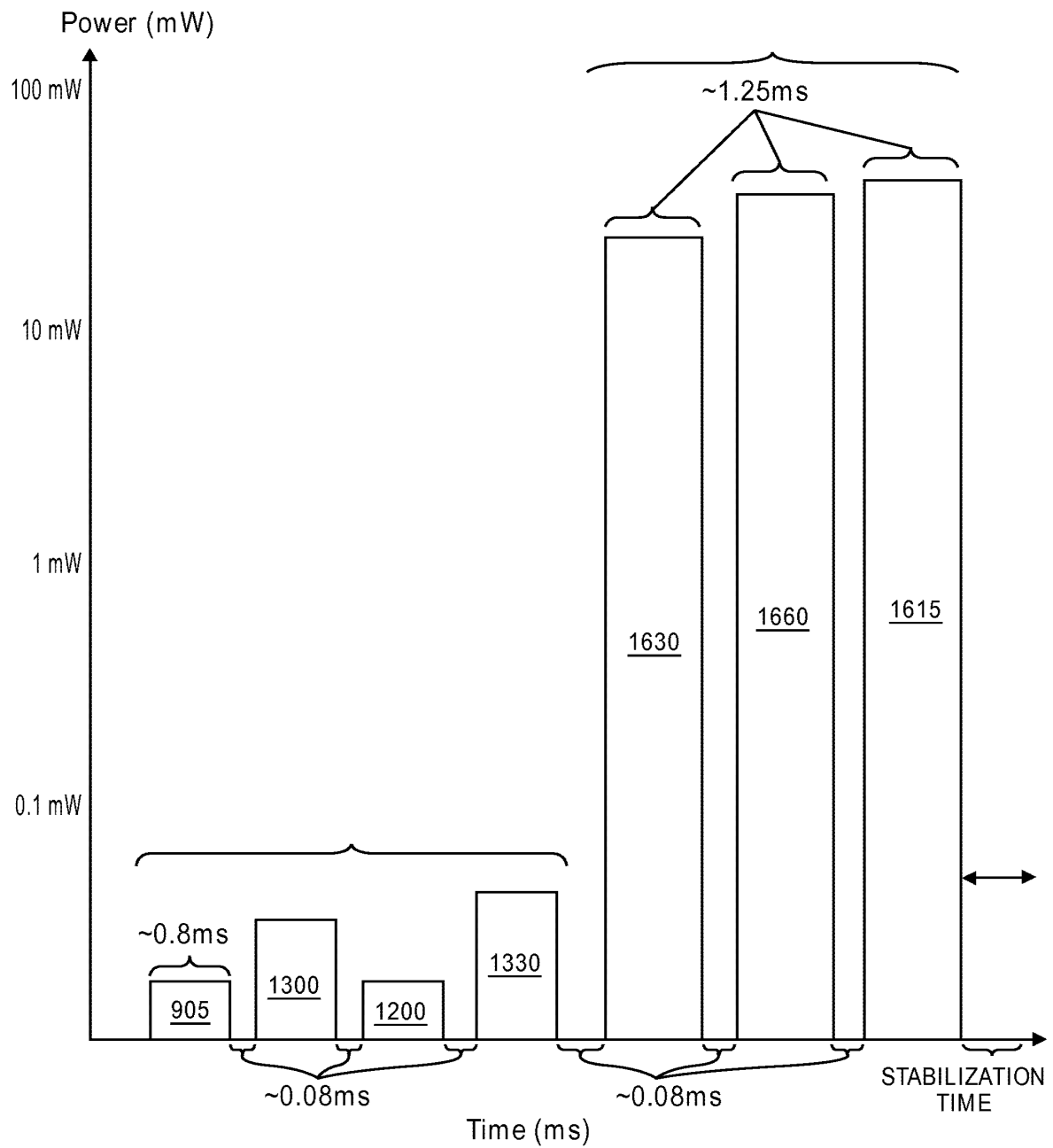


**FIG. 10B**

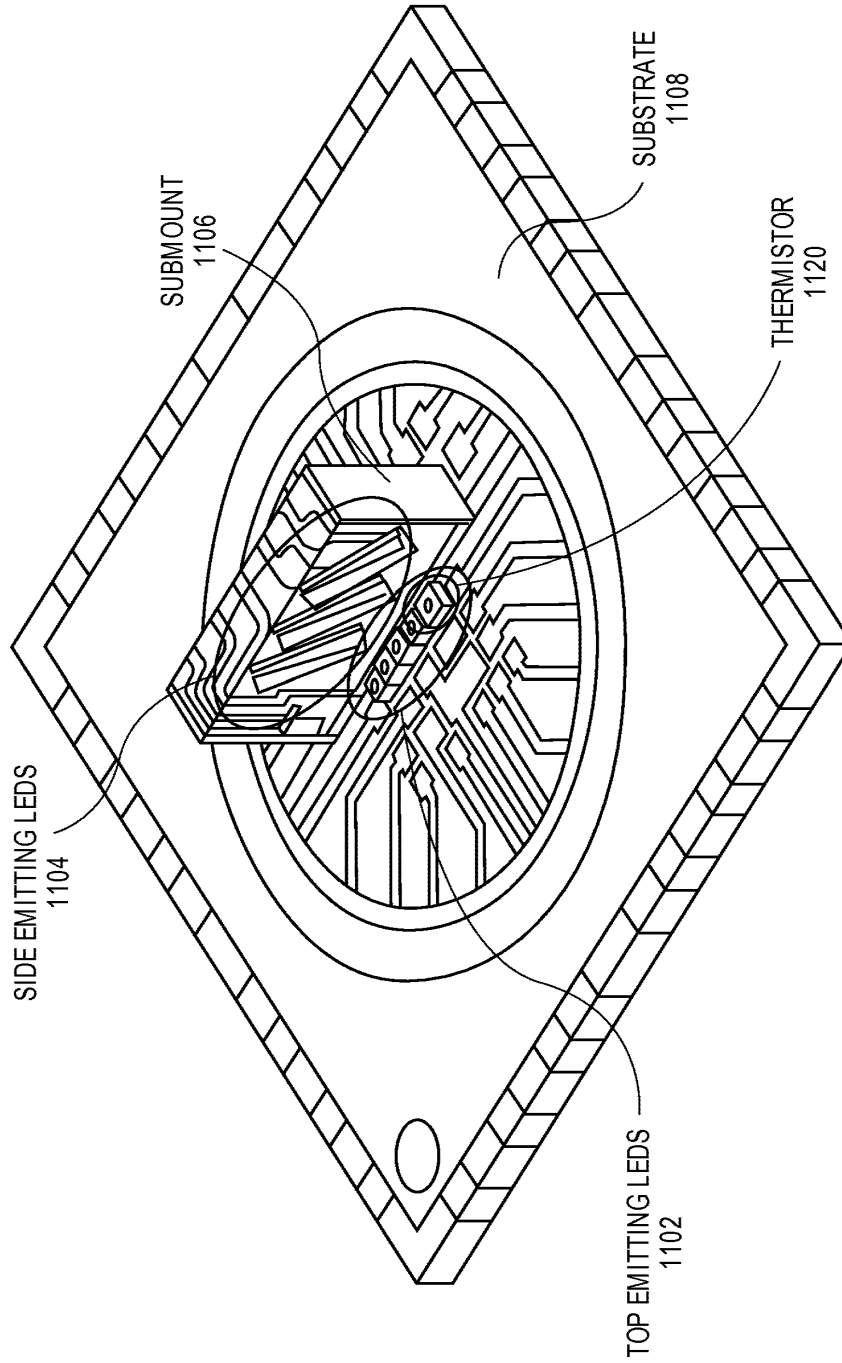
22/65



23/65

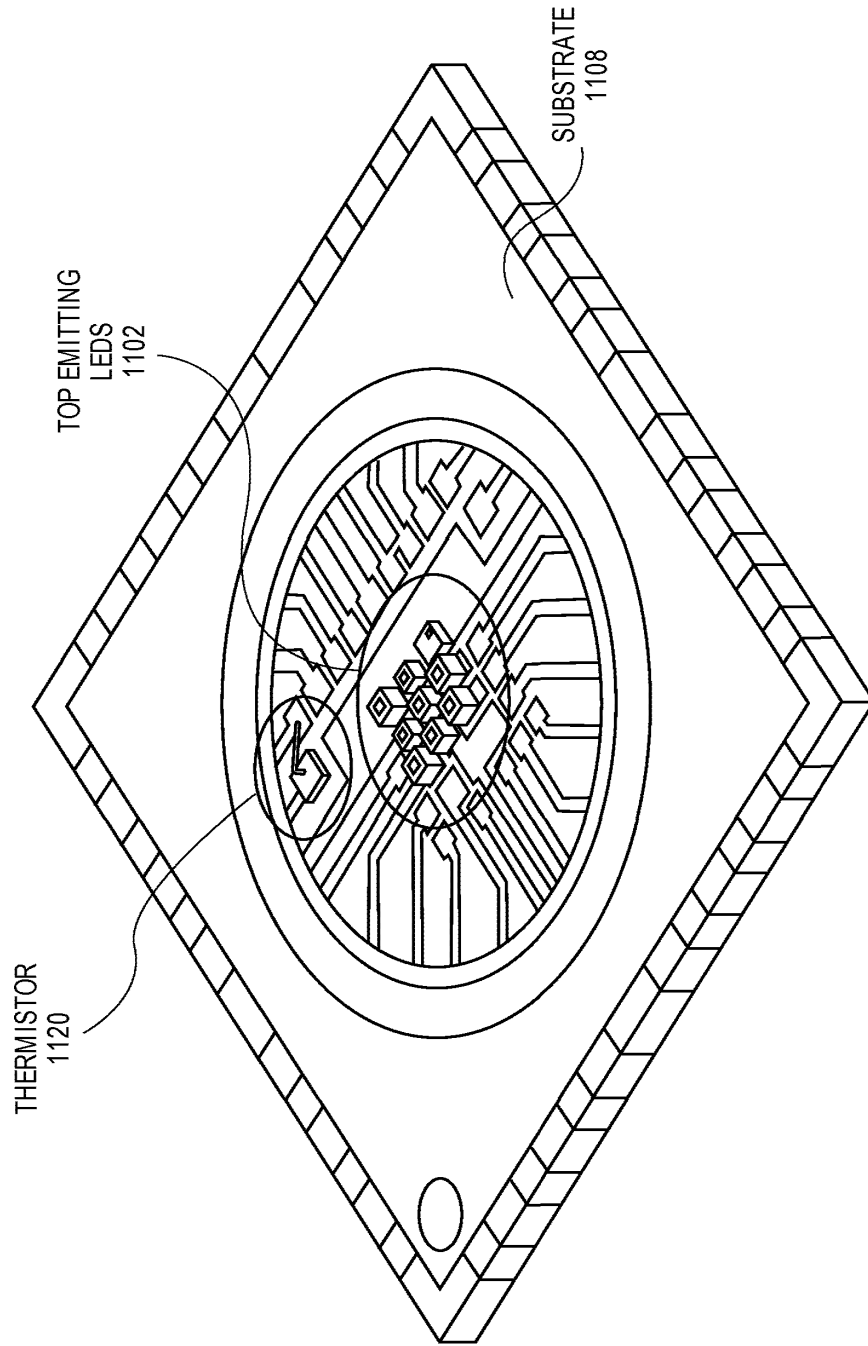
**FIG. 11B**

24/65



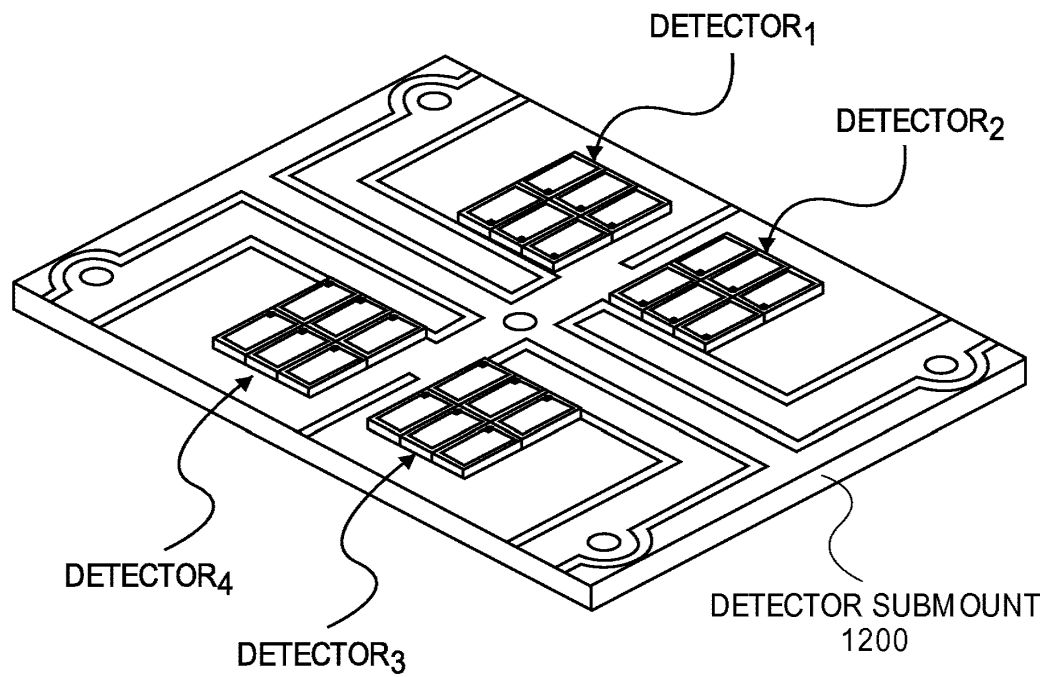
**FIG. 11C**

25/65



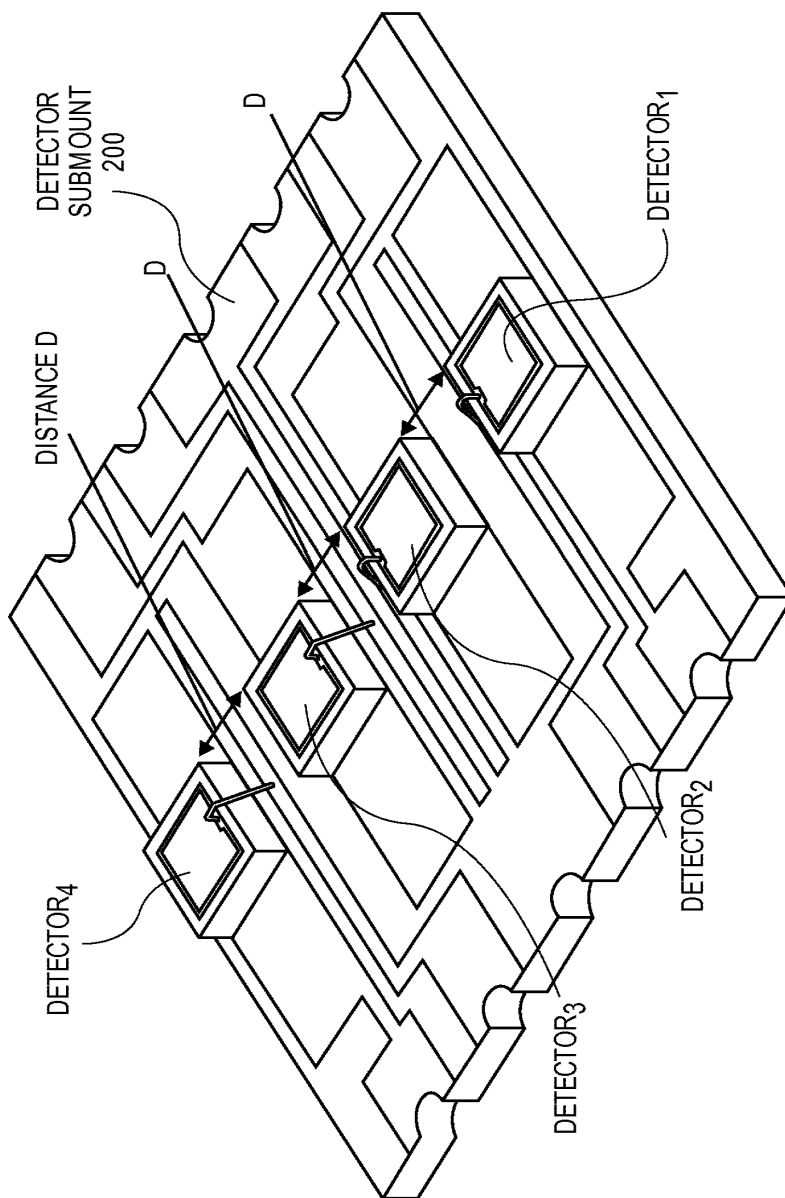
**FIG. 11D**

26/65



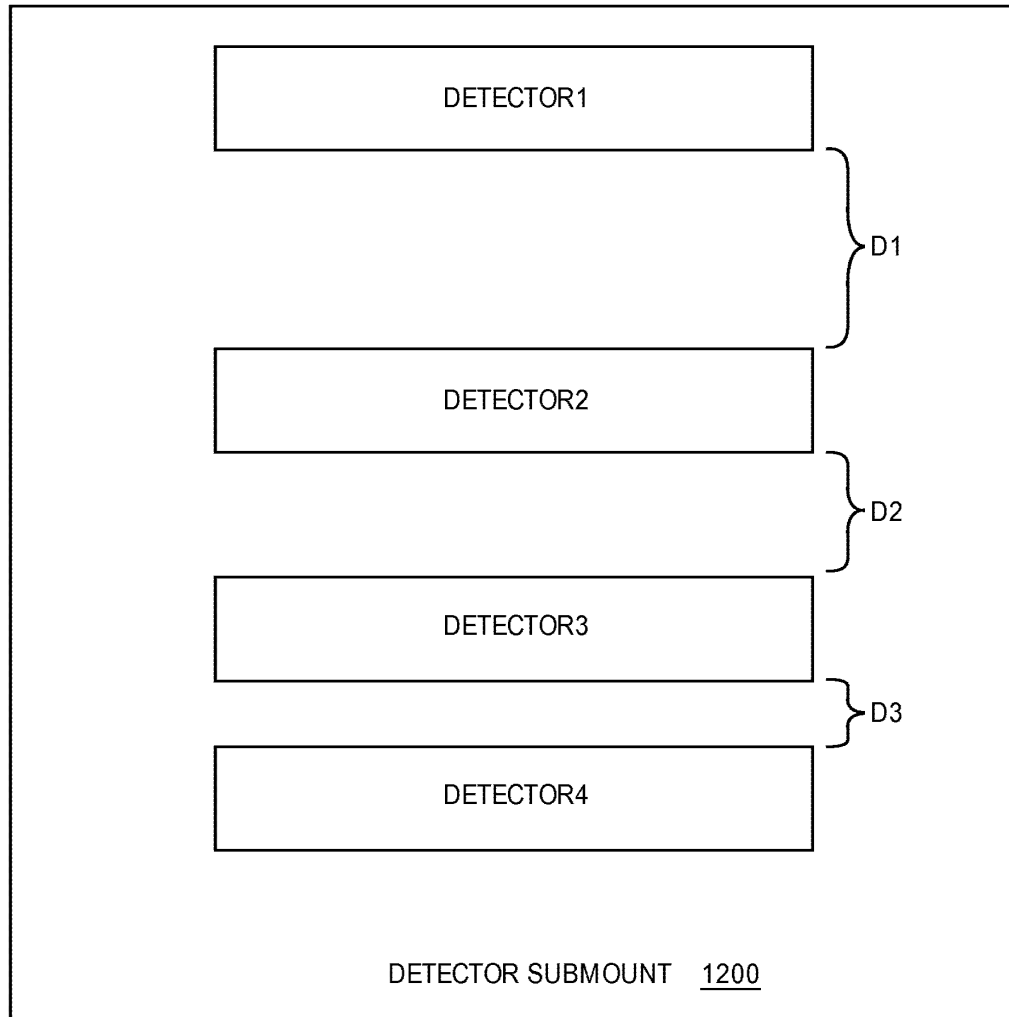
**FIG. 12A**

27/65



**FIG. 12B**

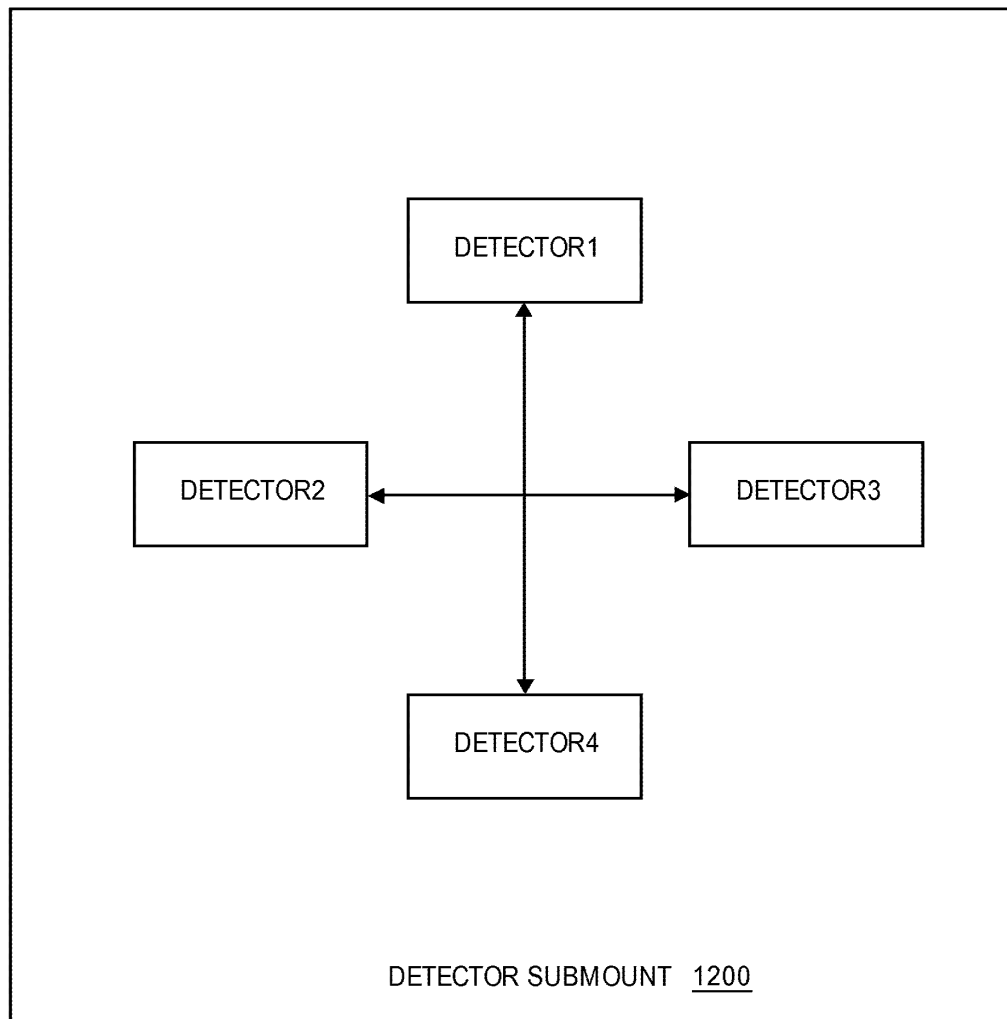
28/65



**FIG. 12C**

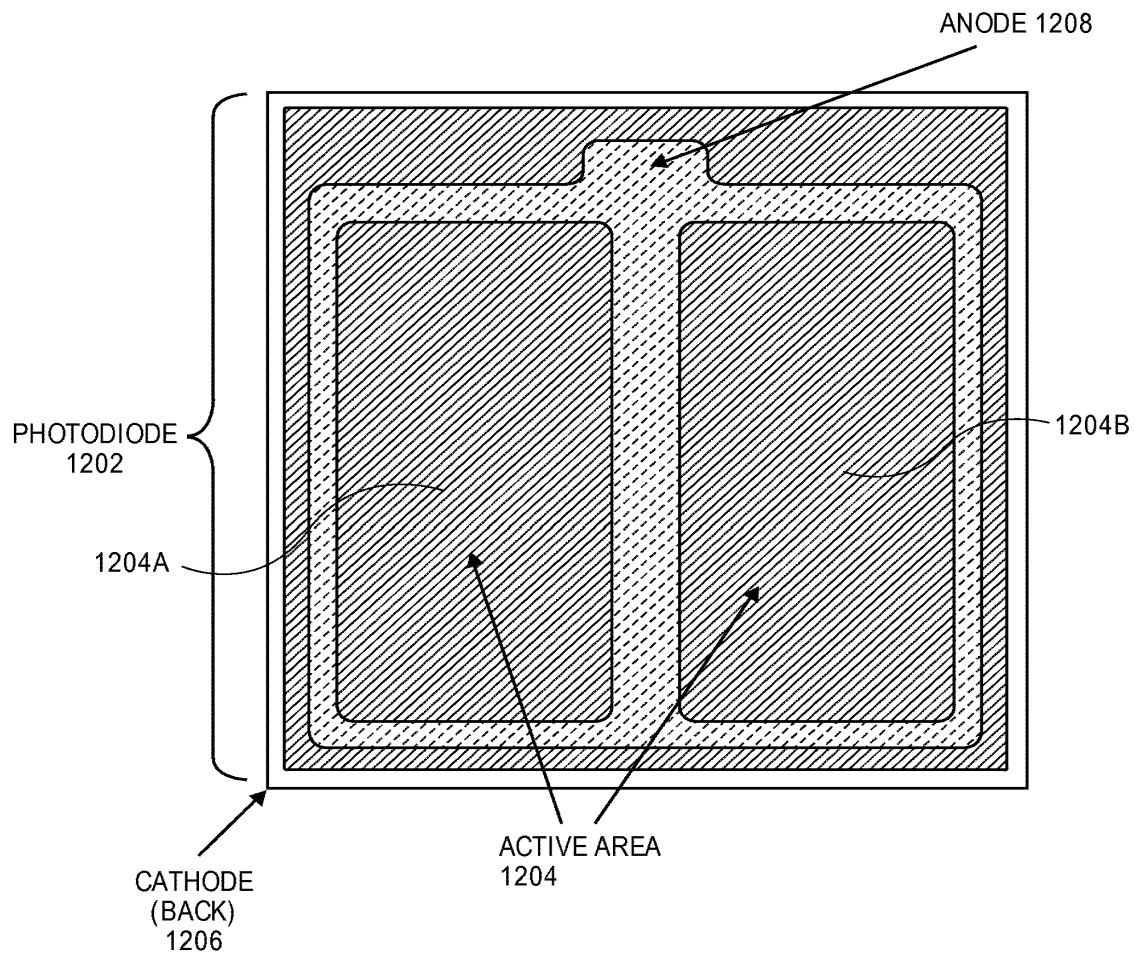


29/65



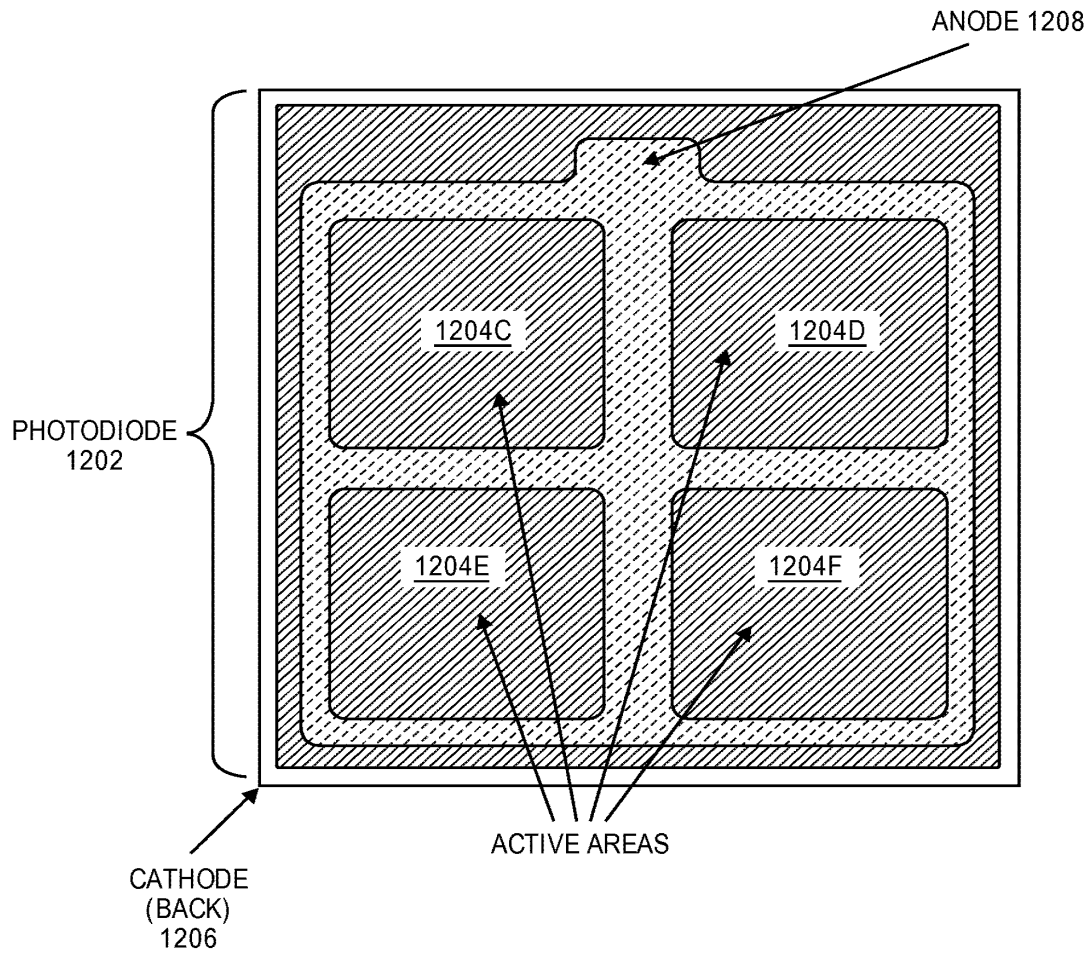
**FIG. 12D**

30/65



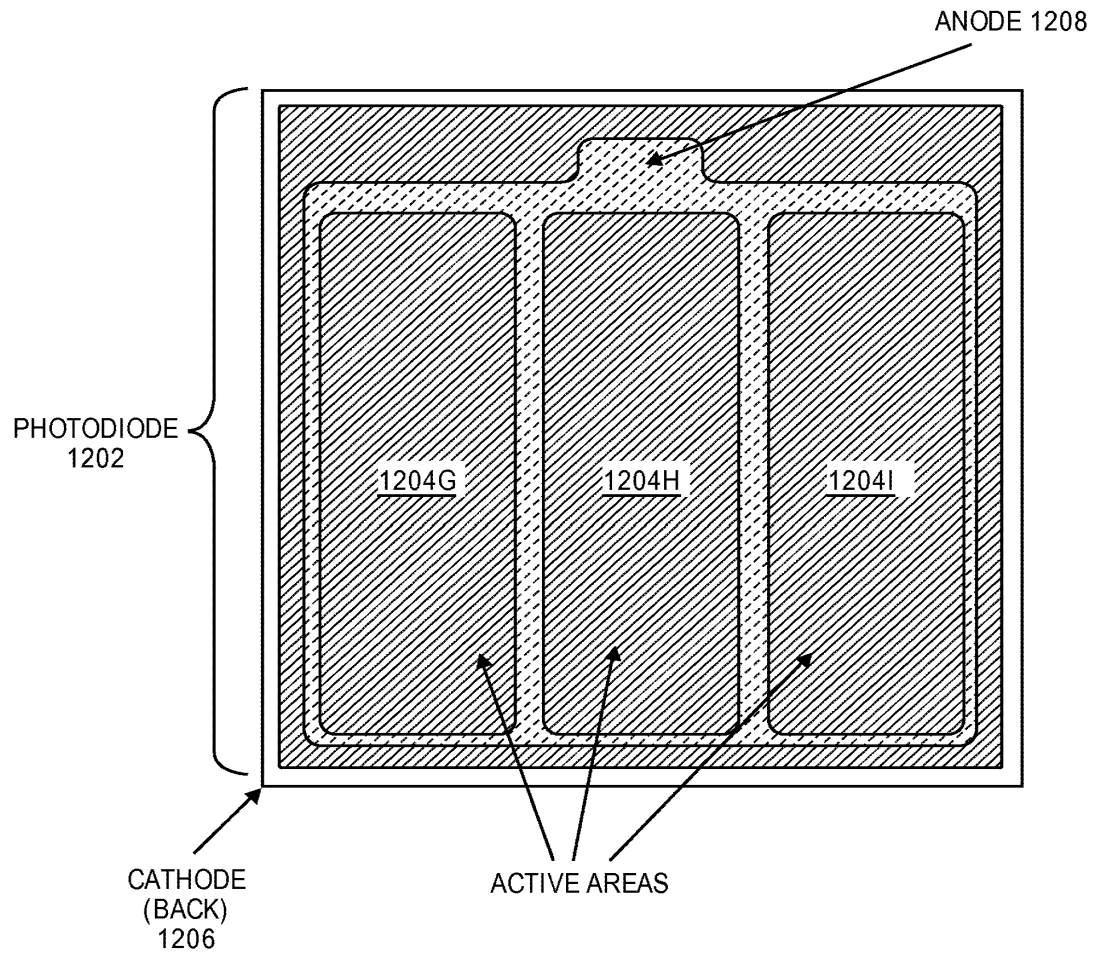
**FIG. 12E**

31/65



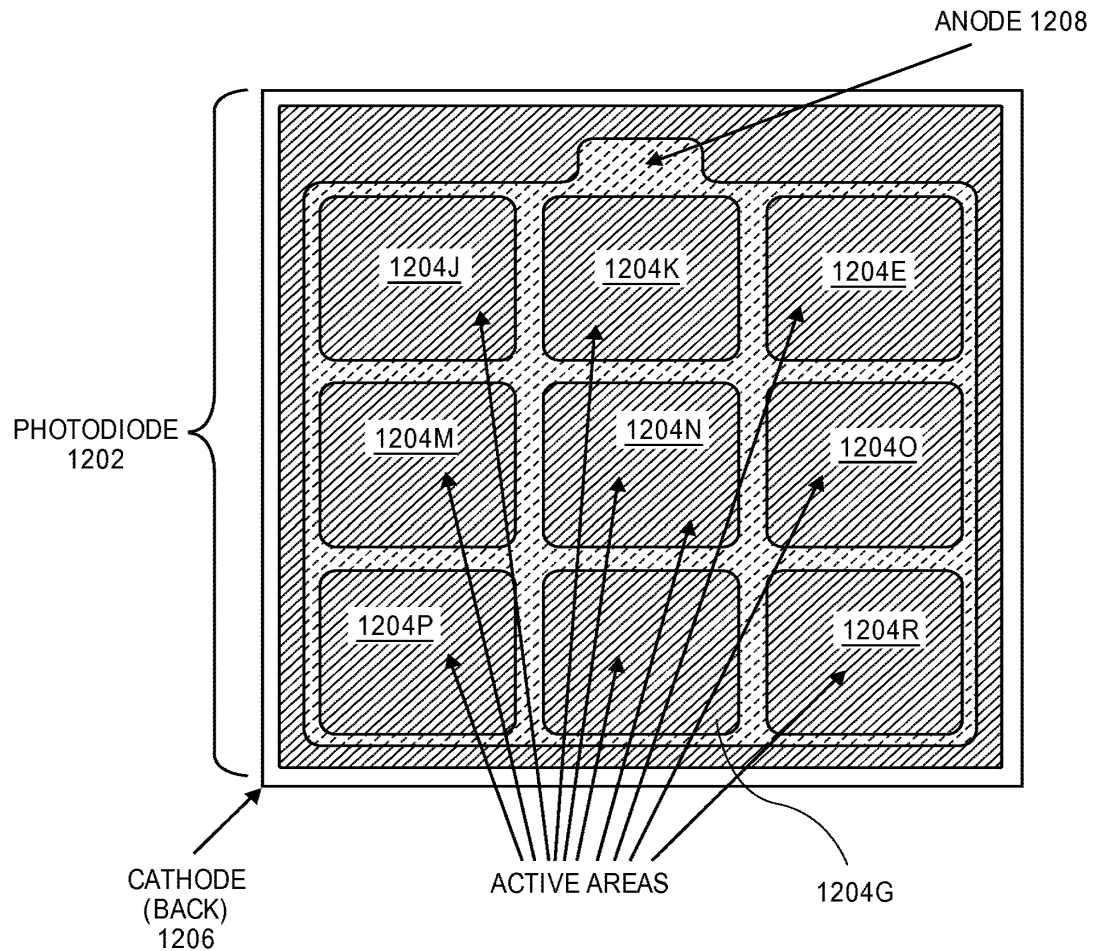
**FIG. 12F**

32/65

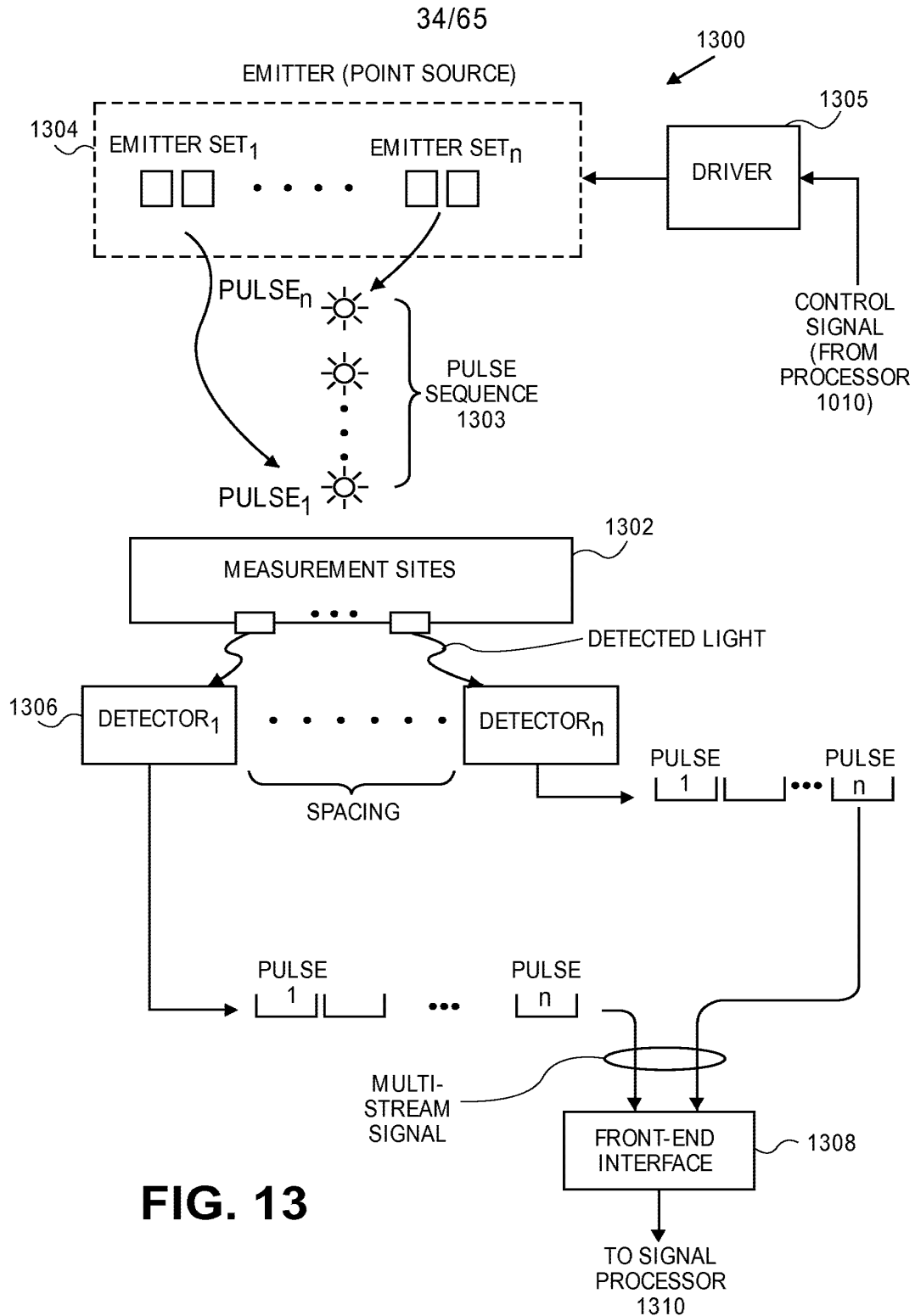


**FIG. 12G**

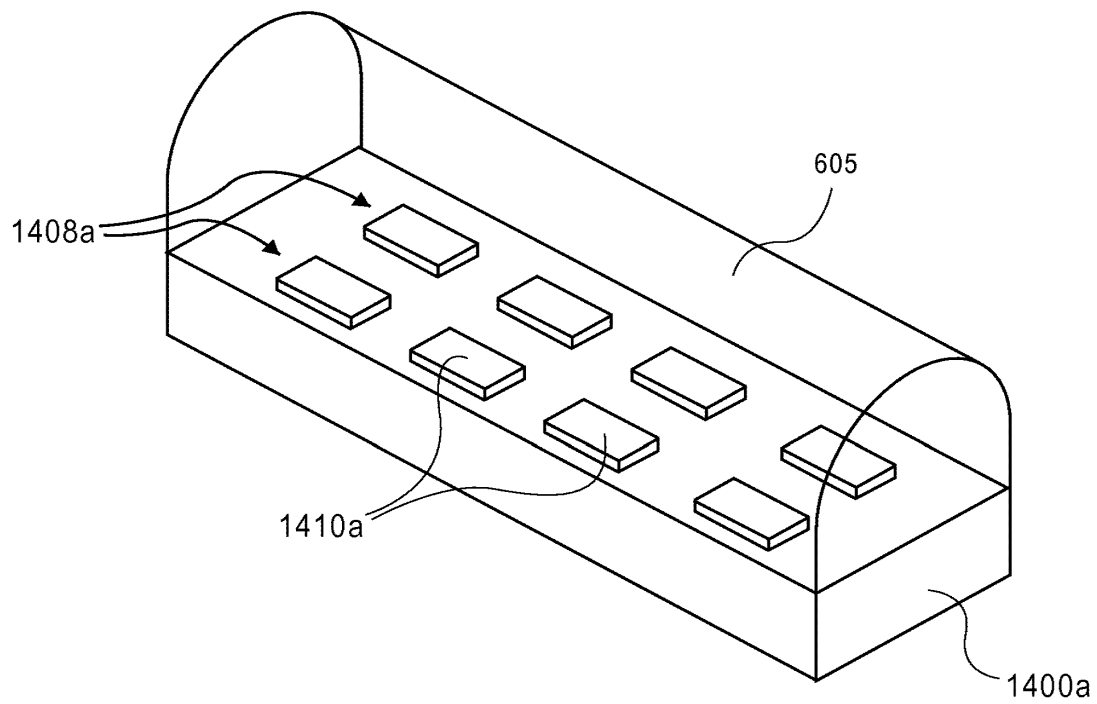
33/65



**FIG. 12H**

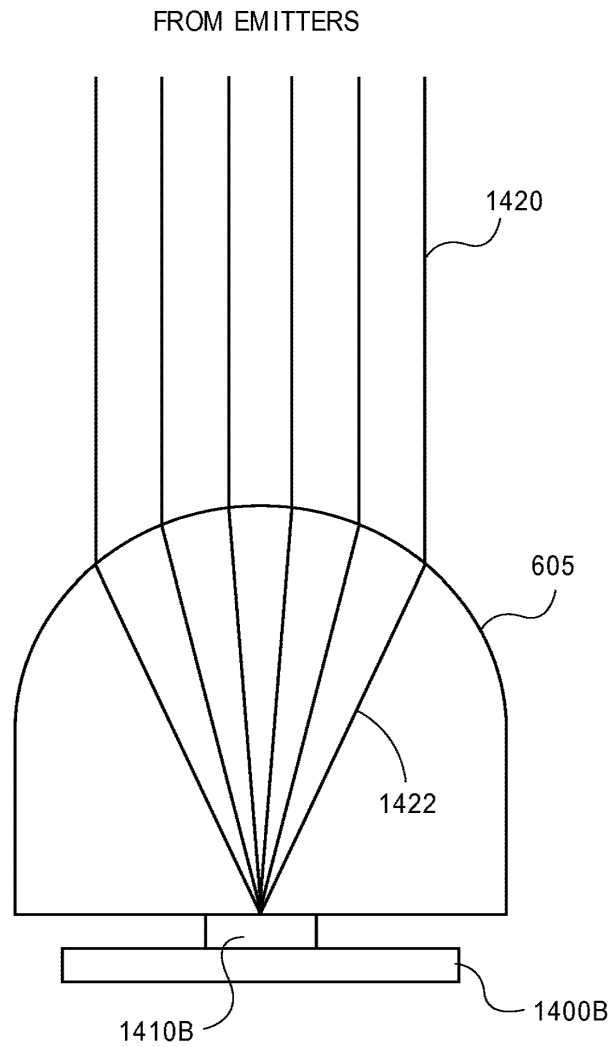


35/65



**FIG. 14A**

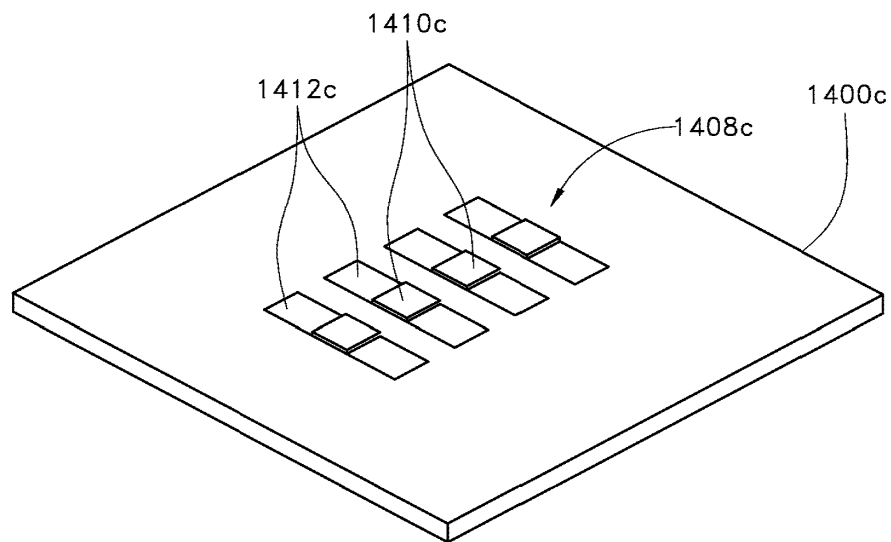
36/65



**FIG. 14B**

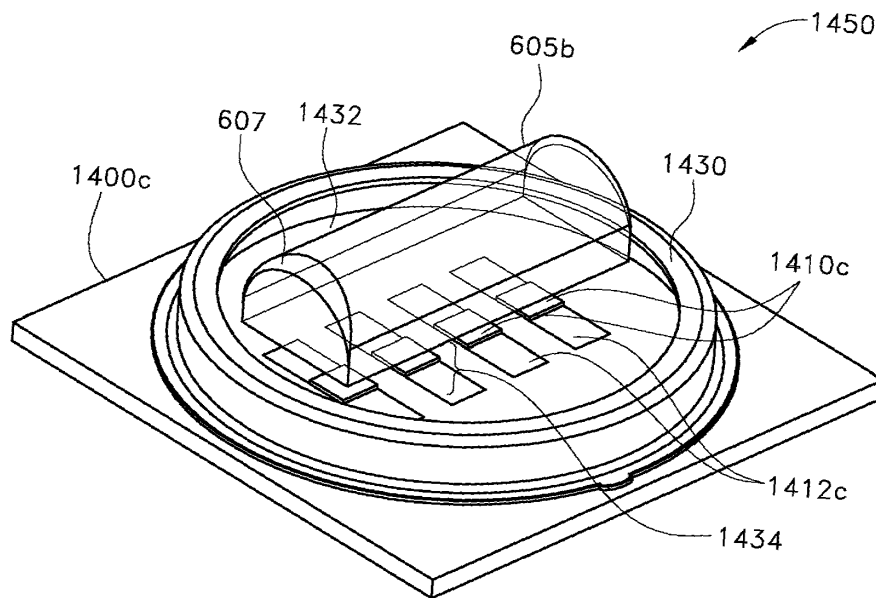


37/65



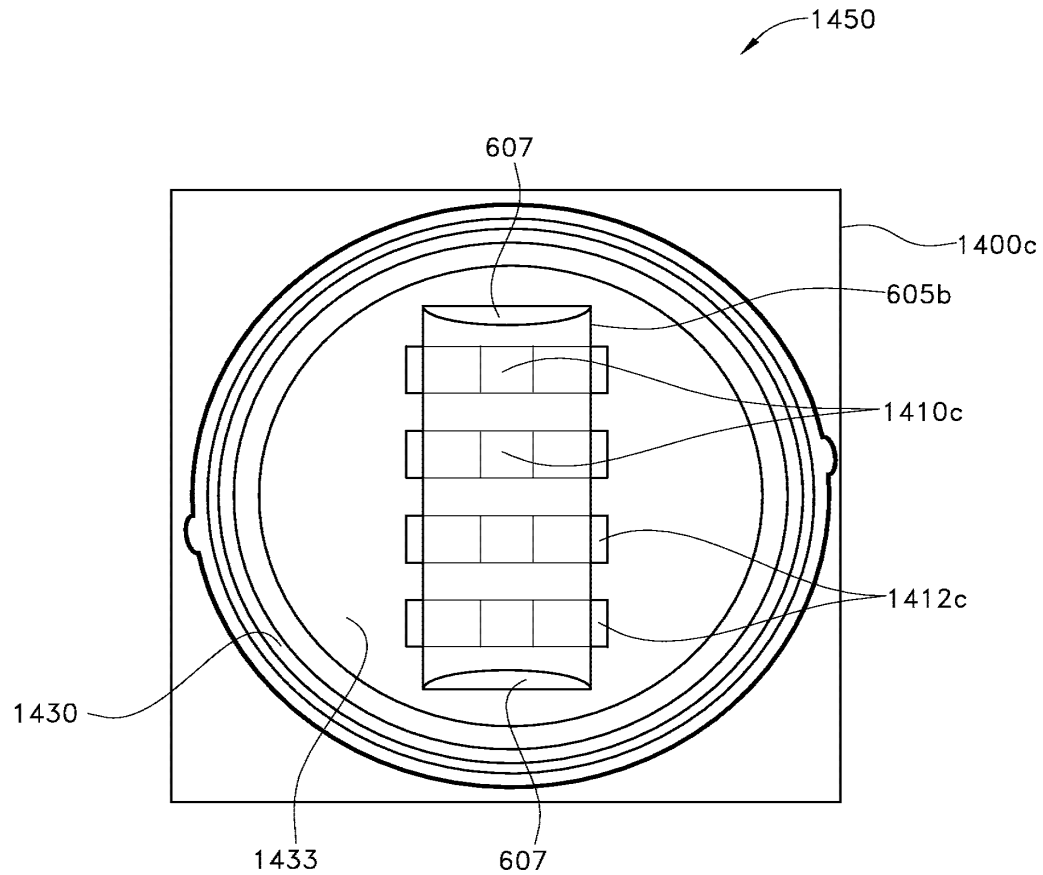
**FIG. 14C**

38/65



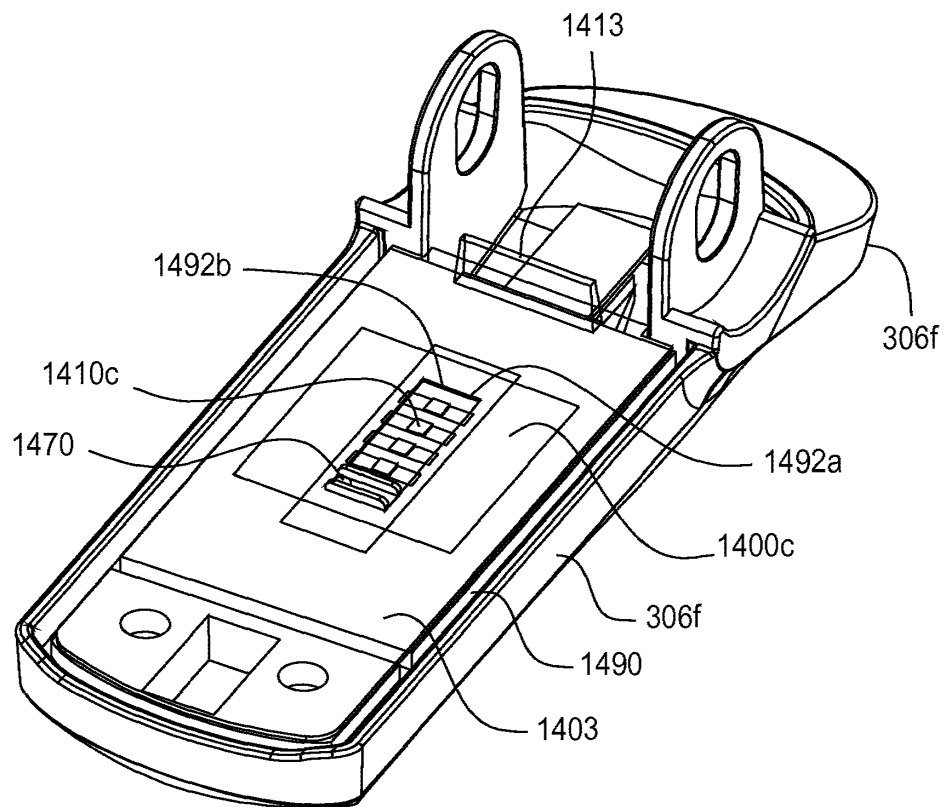
**FIG. 14D**

39/65



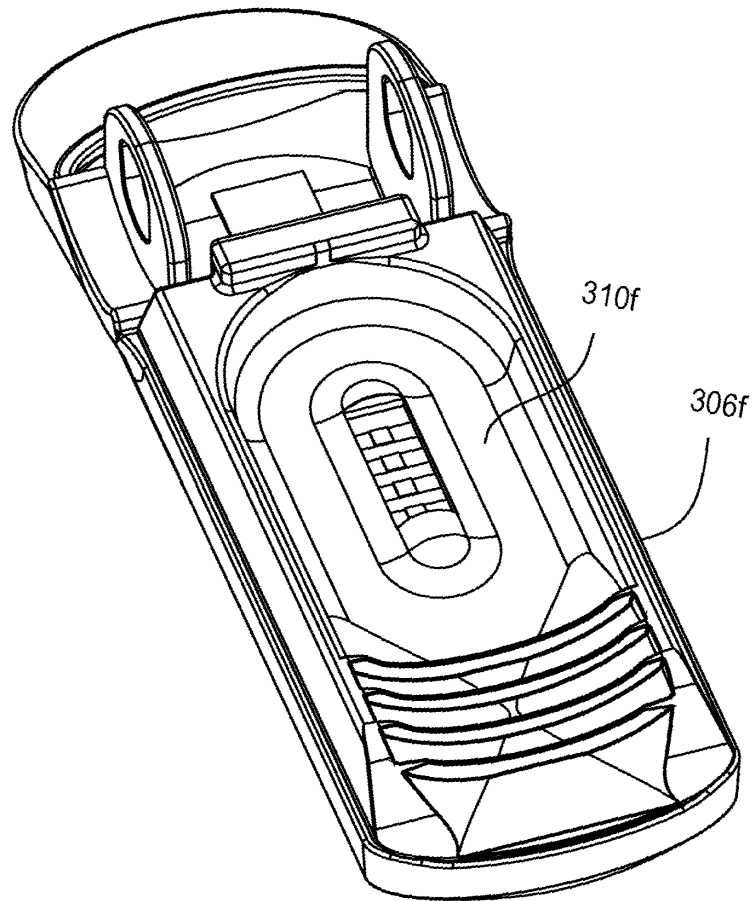
**FIG. 14E**

40/65



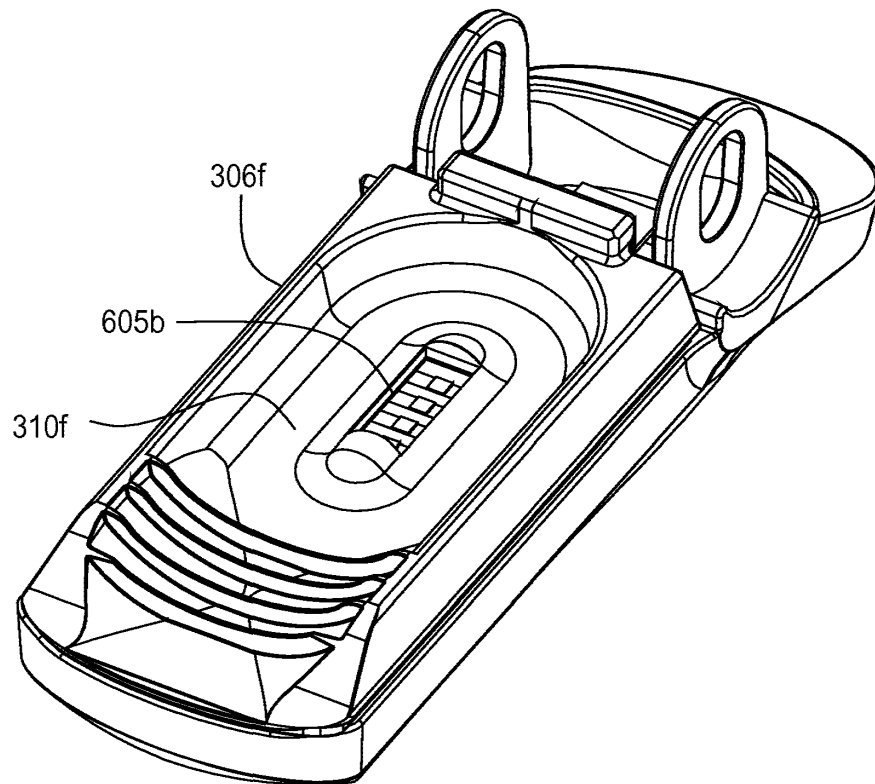
**FIG. 14F**

41/65



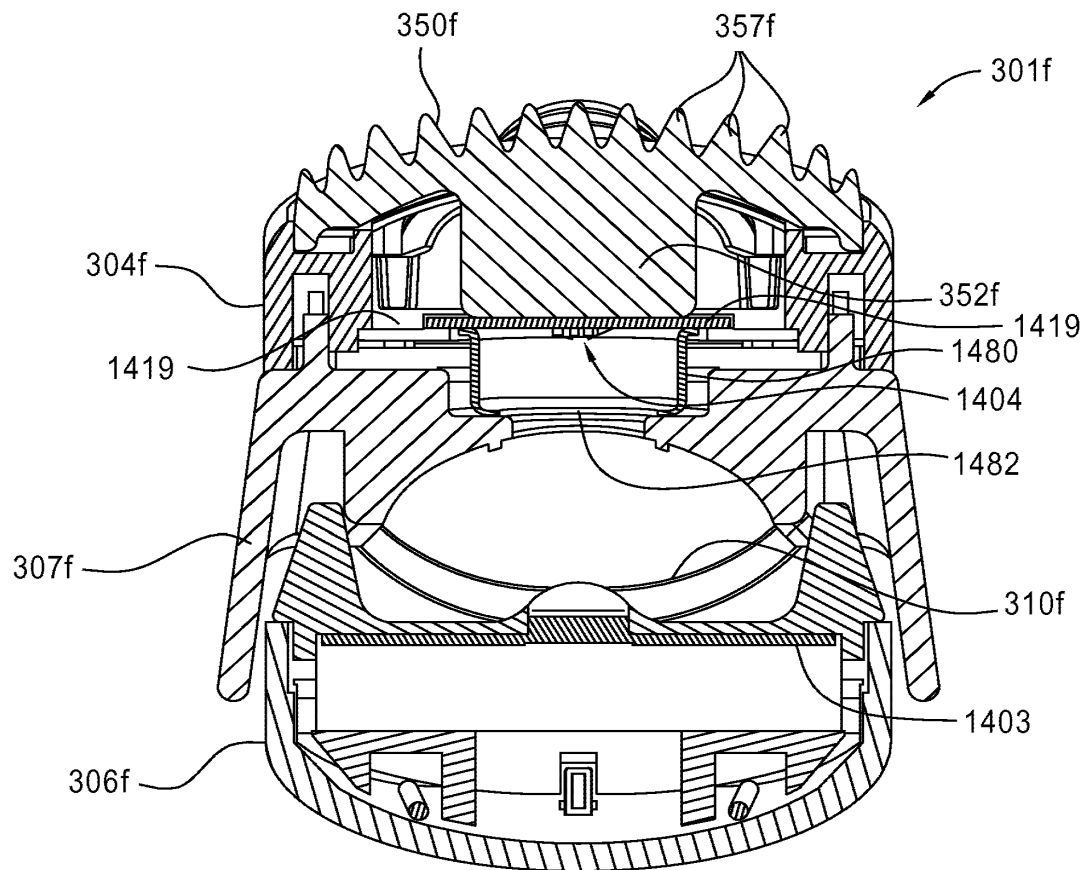
**FIG. 14G**

42/65



**FIG. 14H**

43/65



**FIG. 14I**

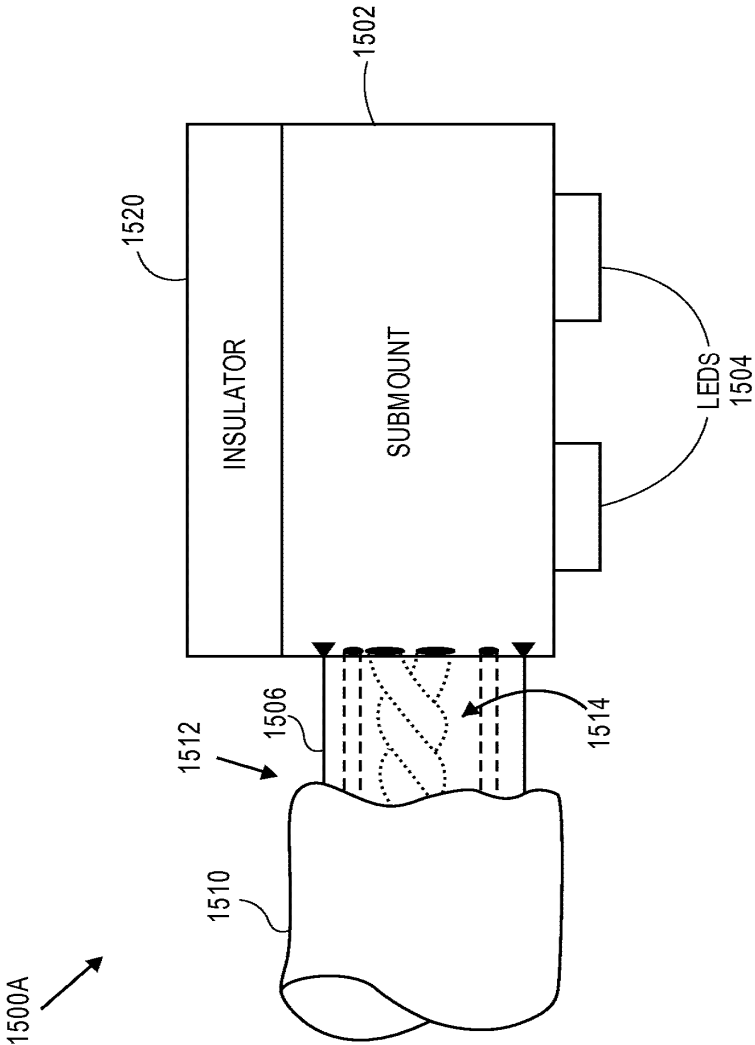


FIG. 15A



45/65

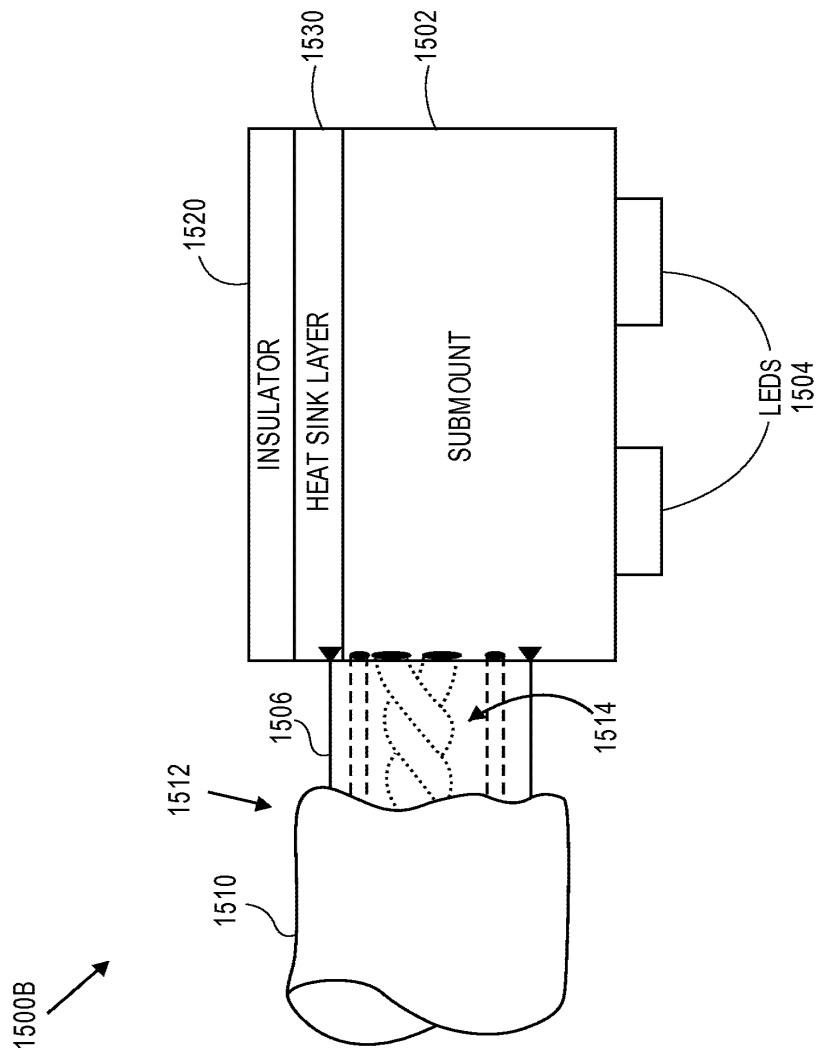


FIG. 15B

Appx59337

46/65

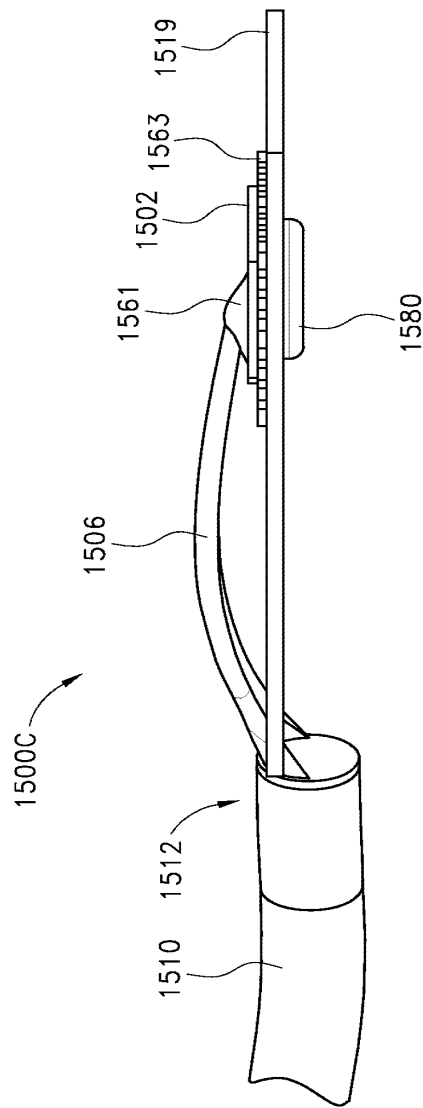
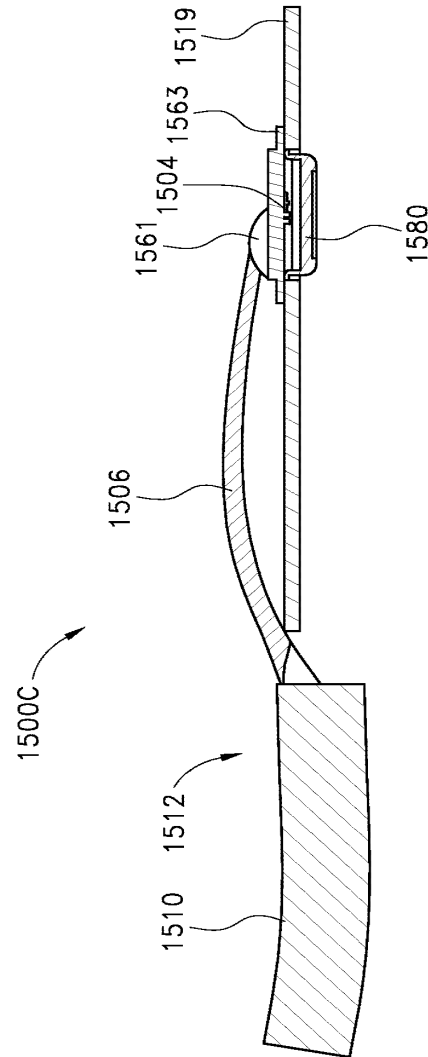
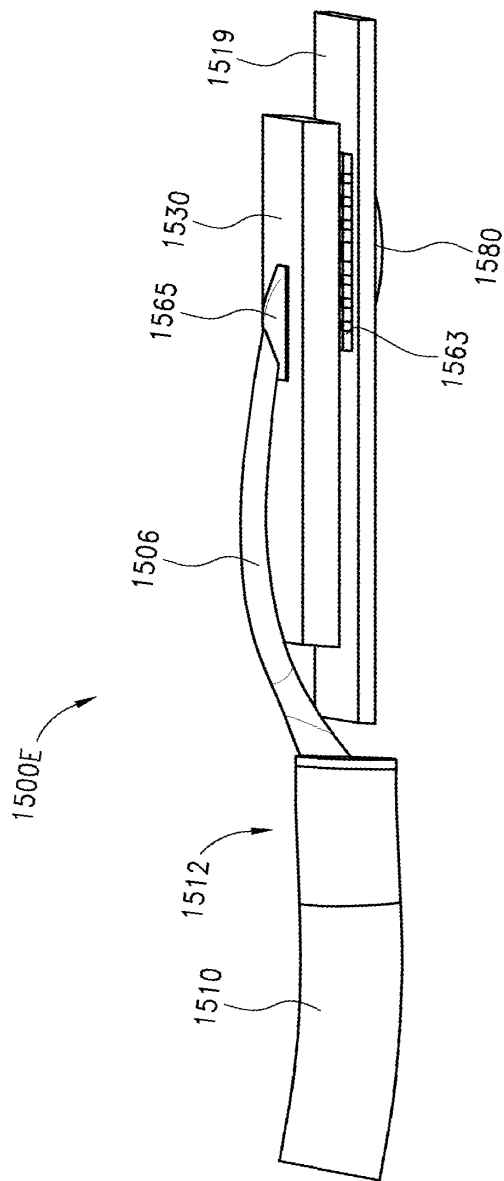


FIG. 15C

47/65

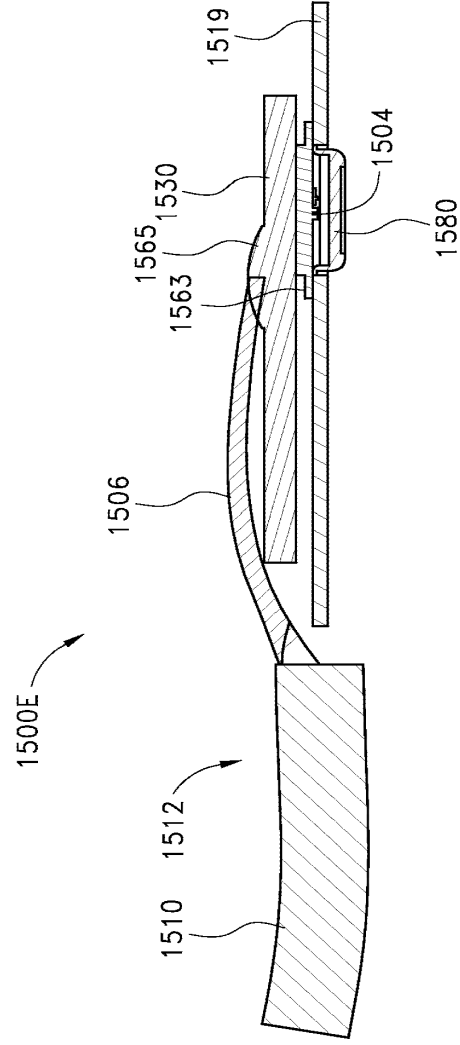


**FIG. 15D**



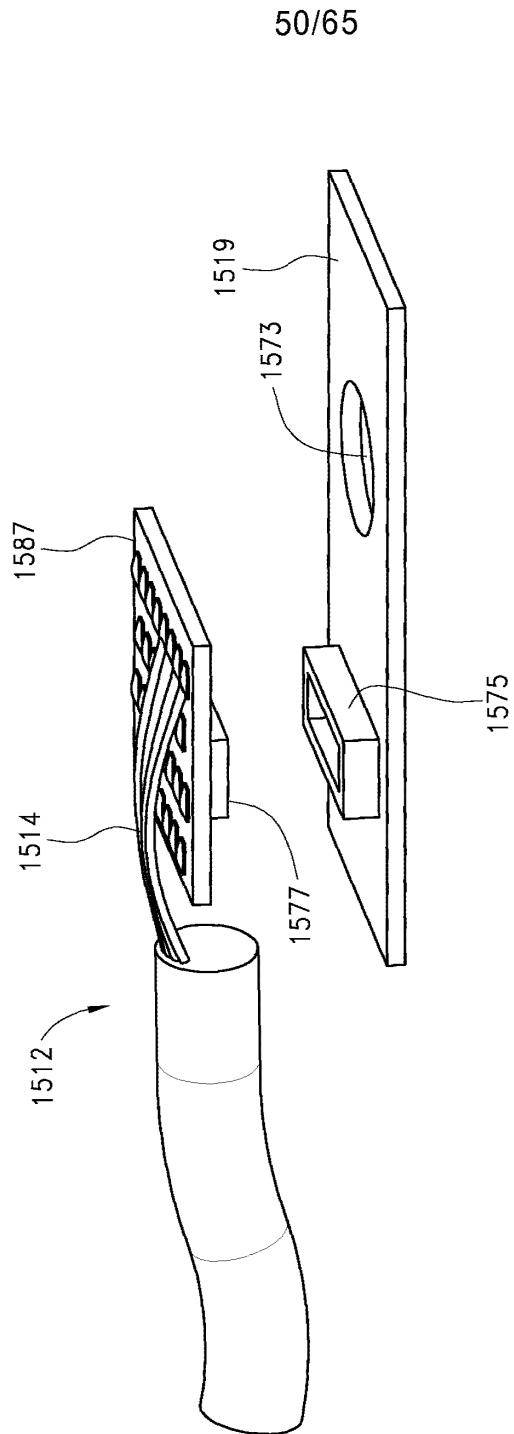
**FIG. 15E**

48/65

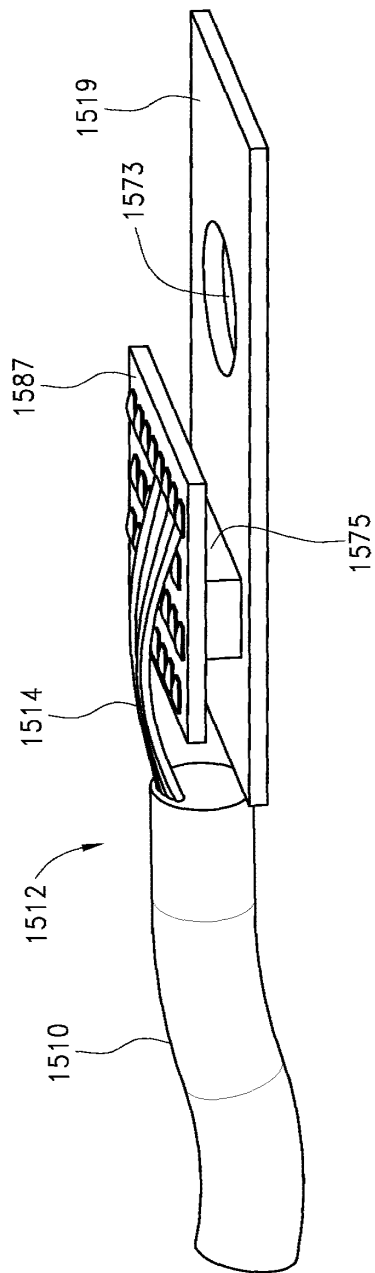


49/65

**FIG. 15F**



**FIG. 15G**



**FIG. 15H**

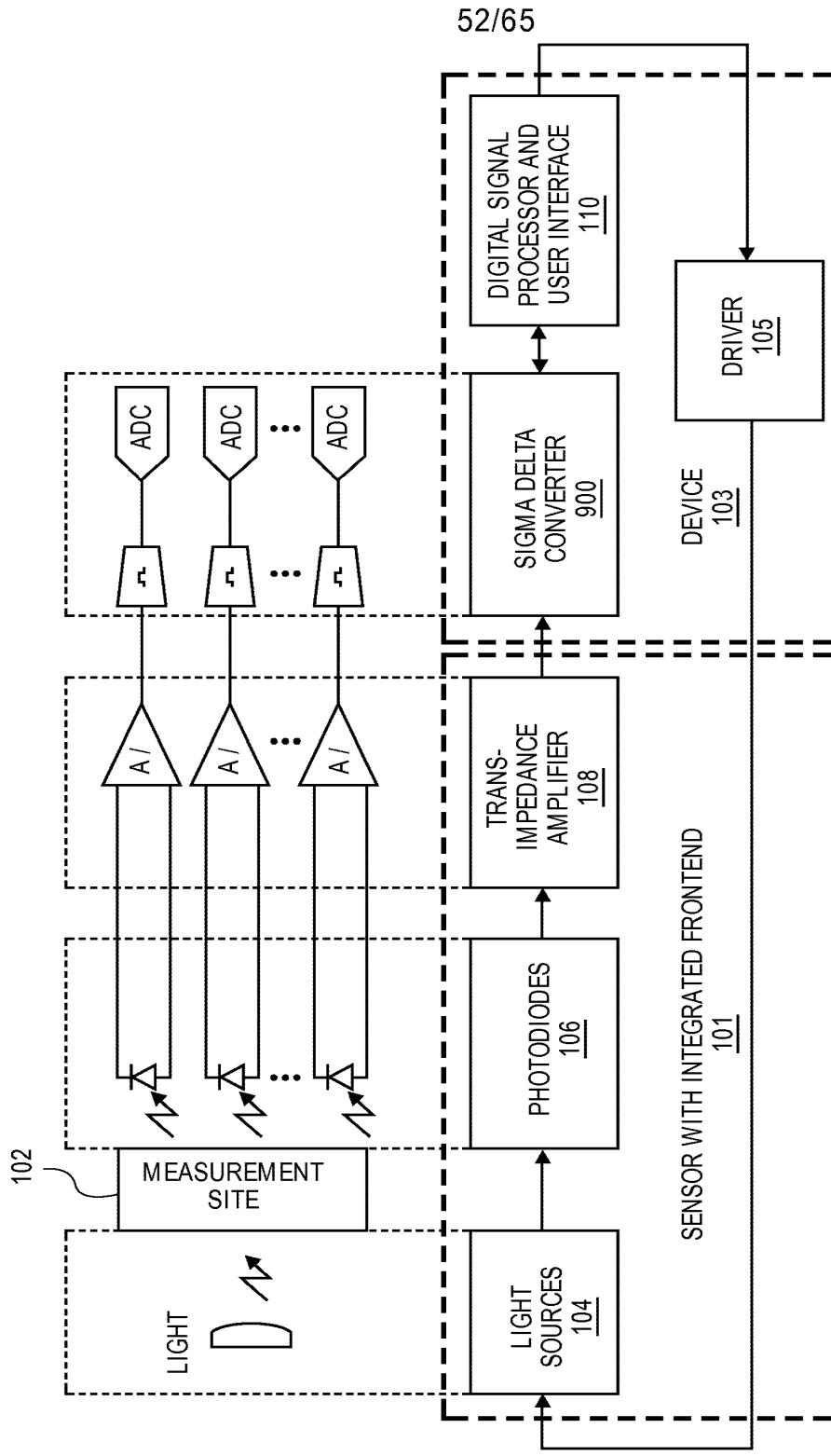
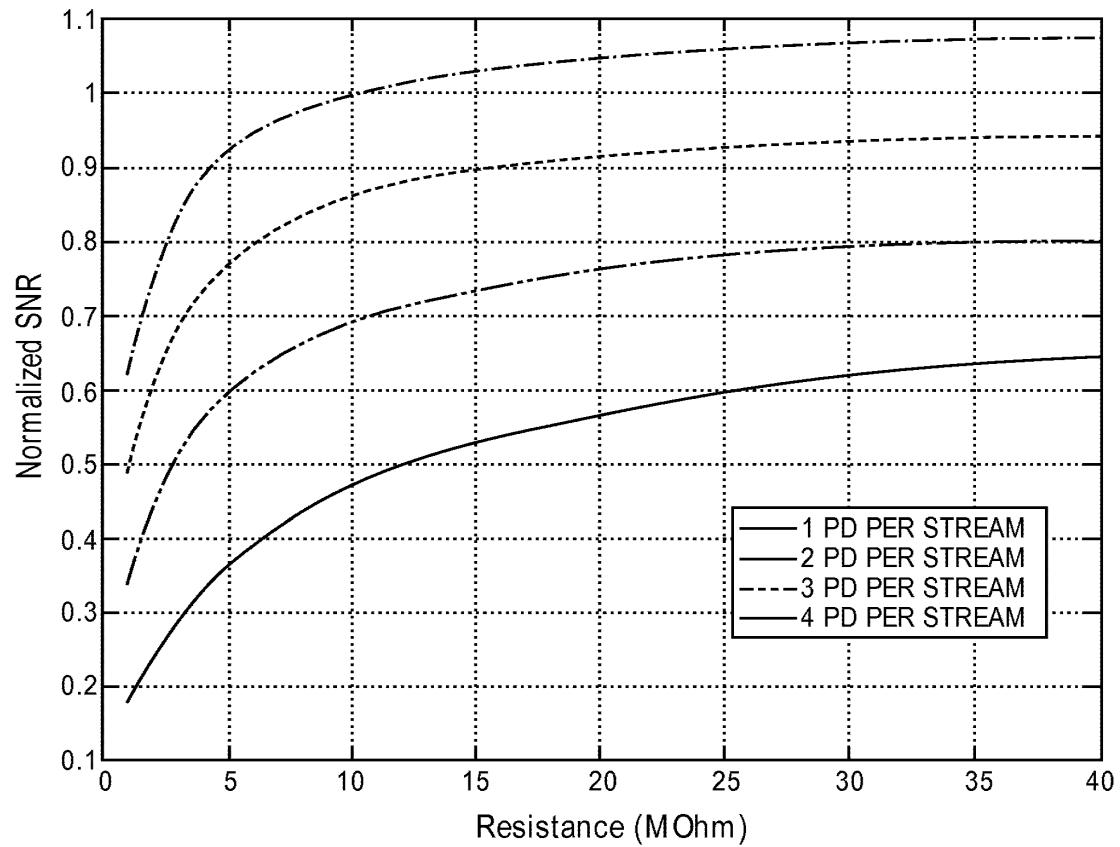
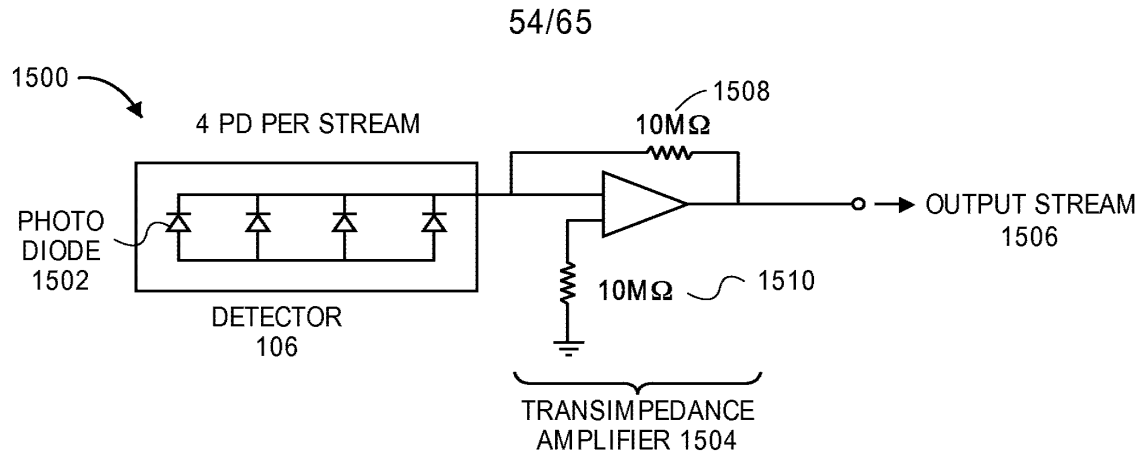


FIG. 151

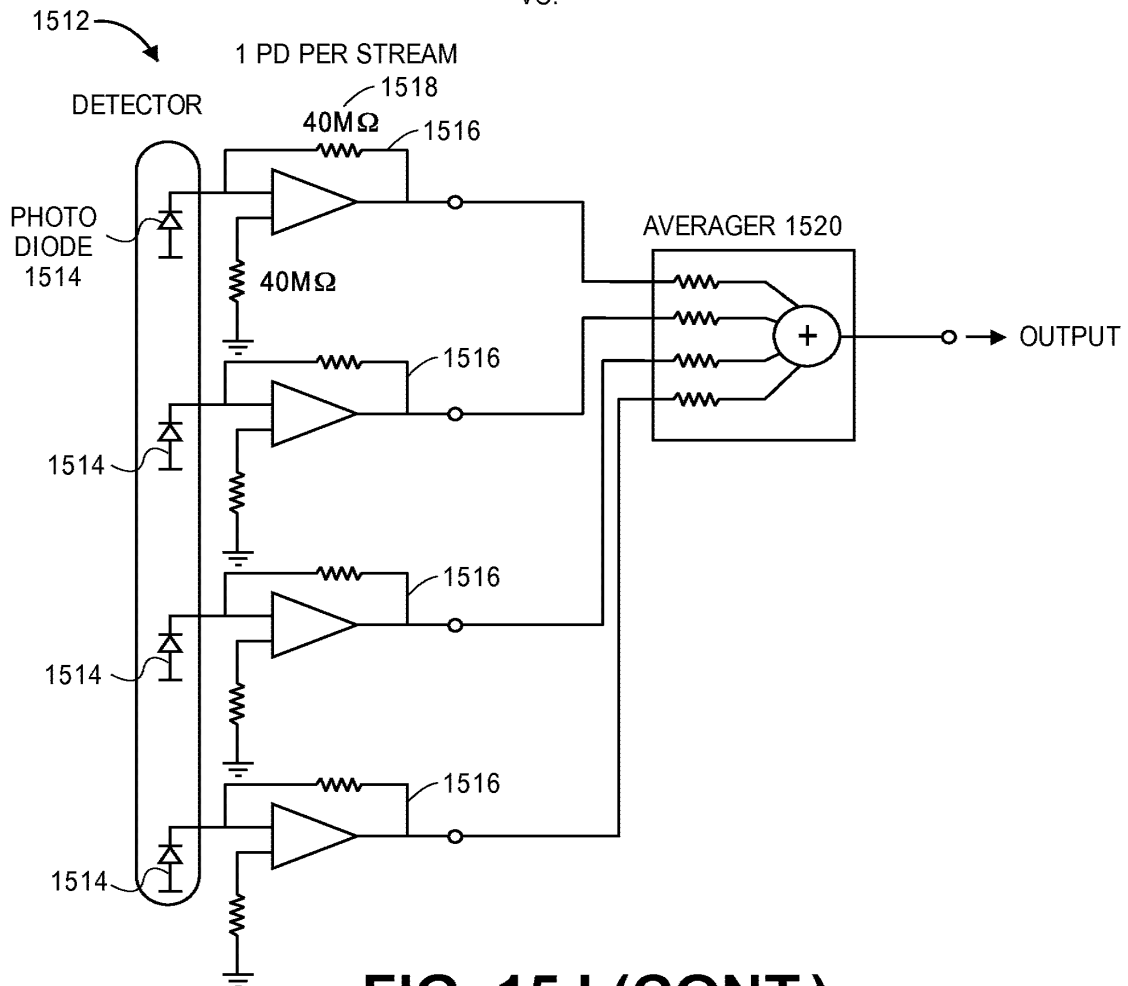


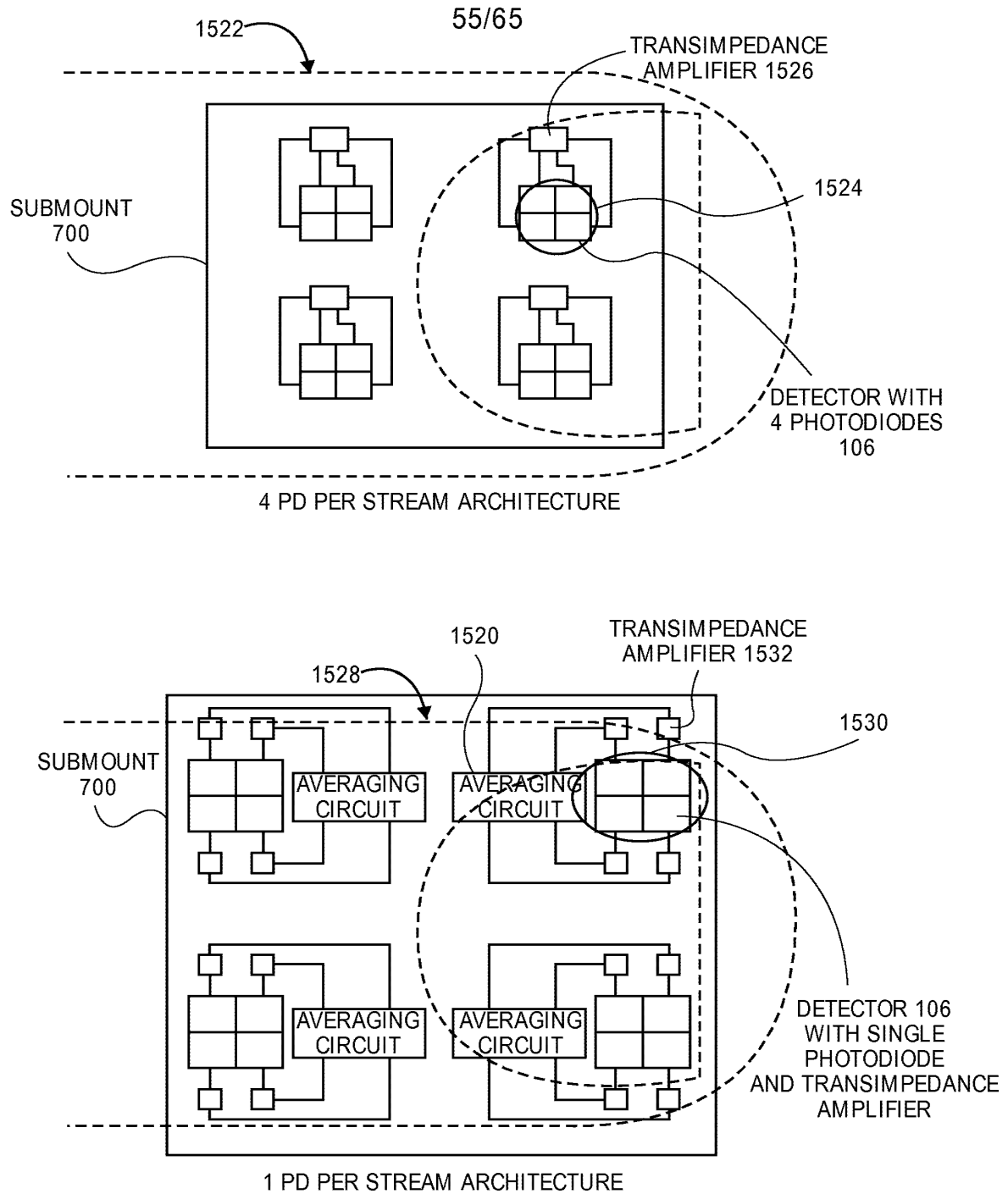
53/65

**FIG. 15J**

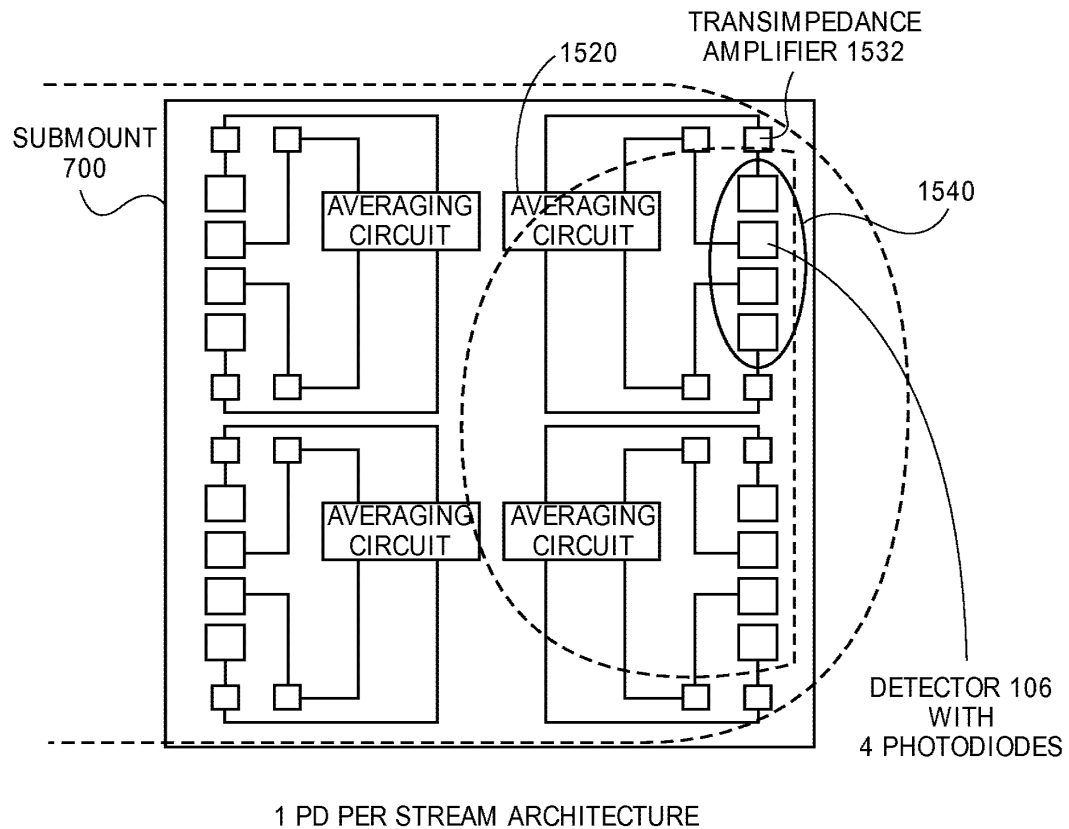
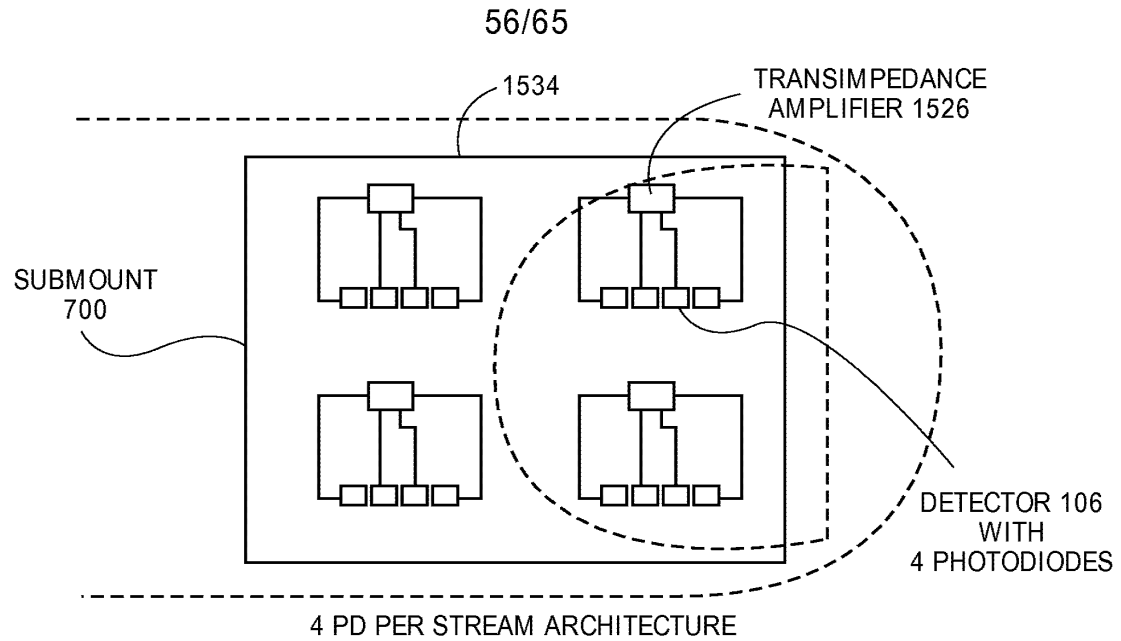


VS.

**FIG. 15J (CONT.)**

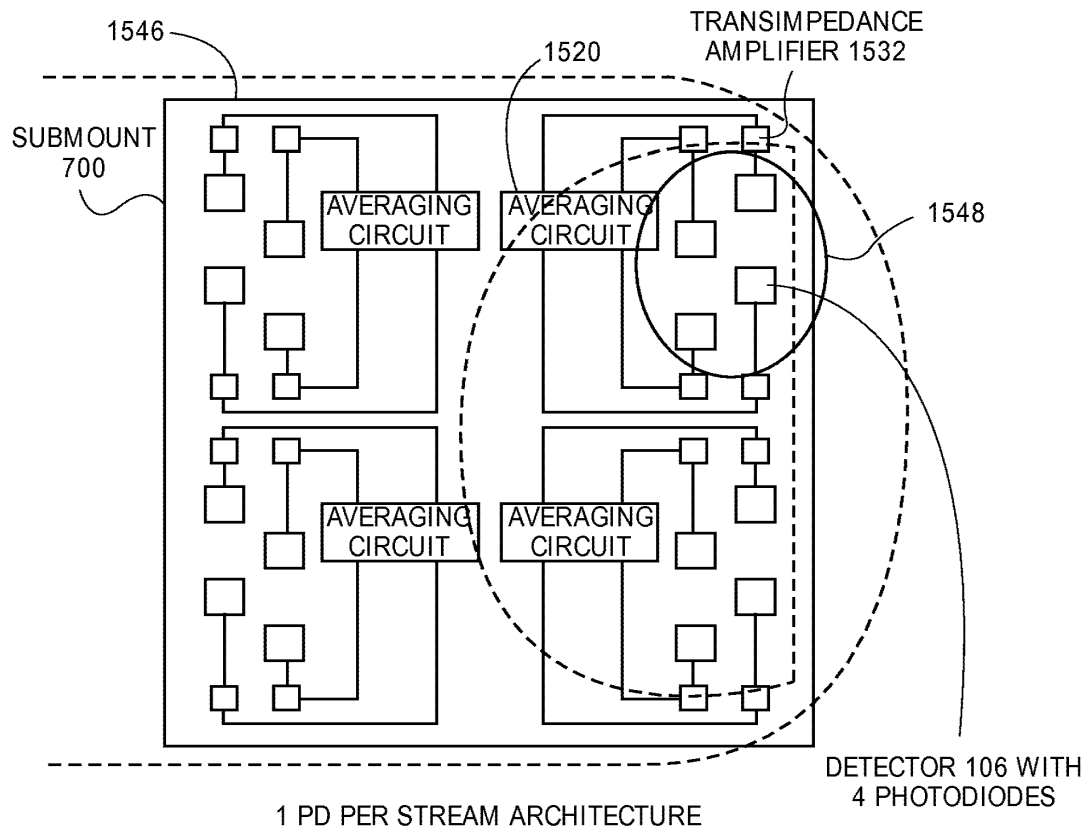
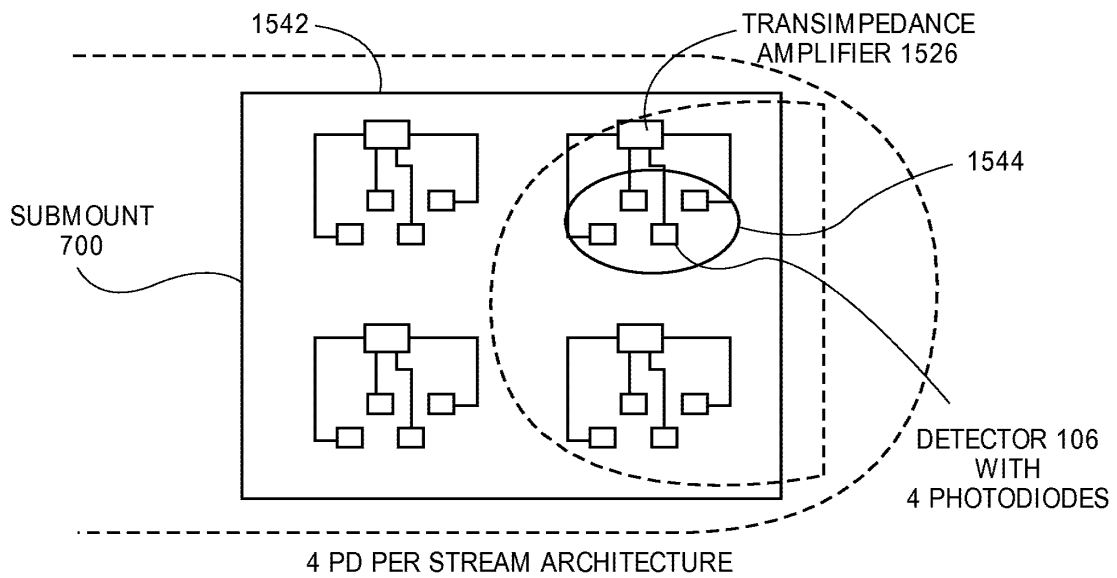


**FIG. 15K**



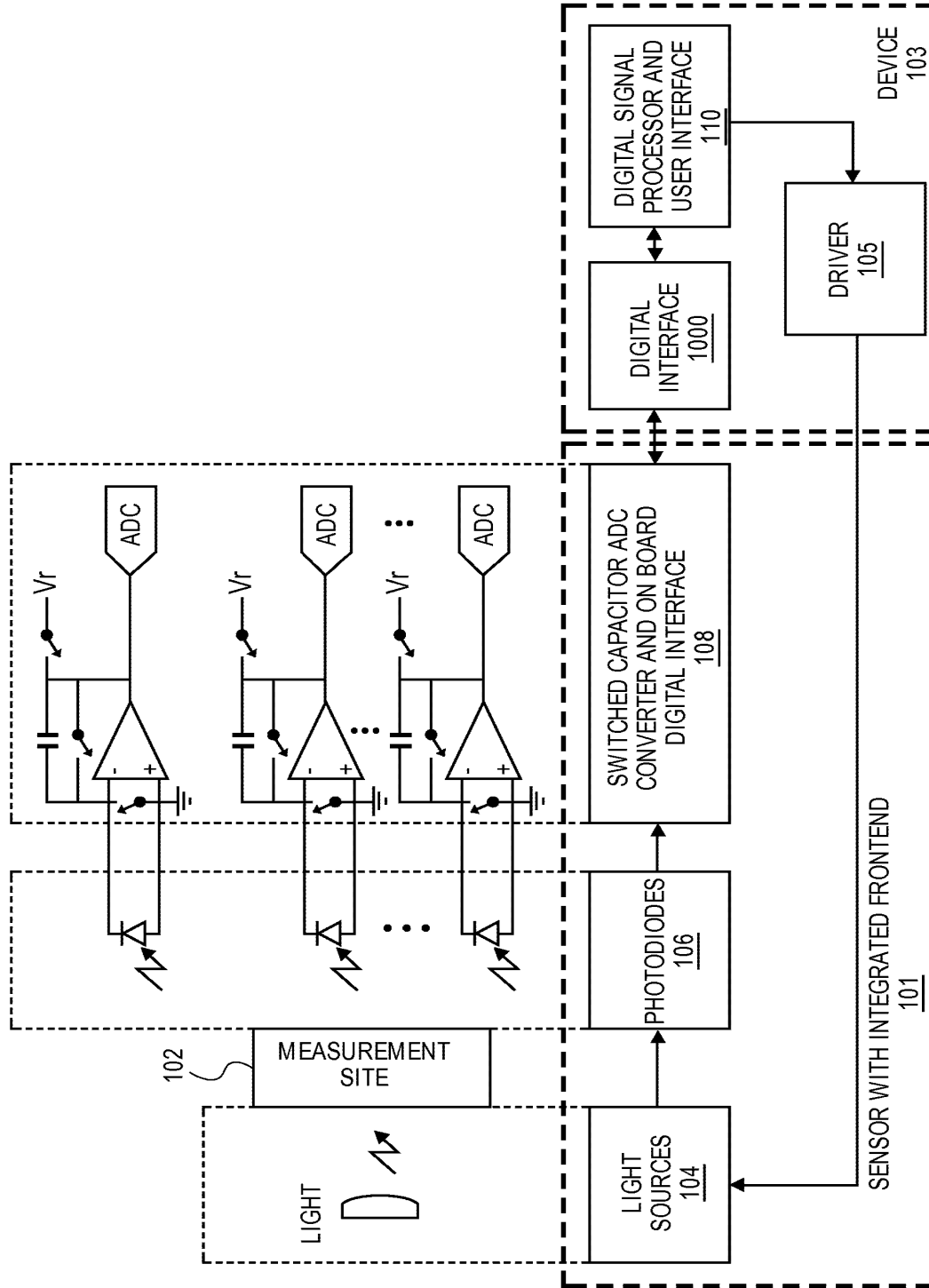
**FIG. 15K (CONT.)**

57/65



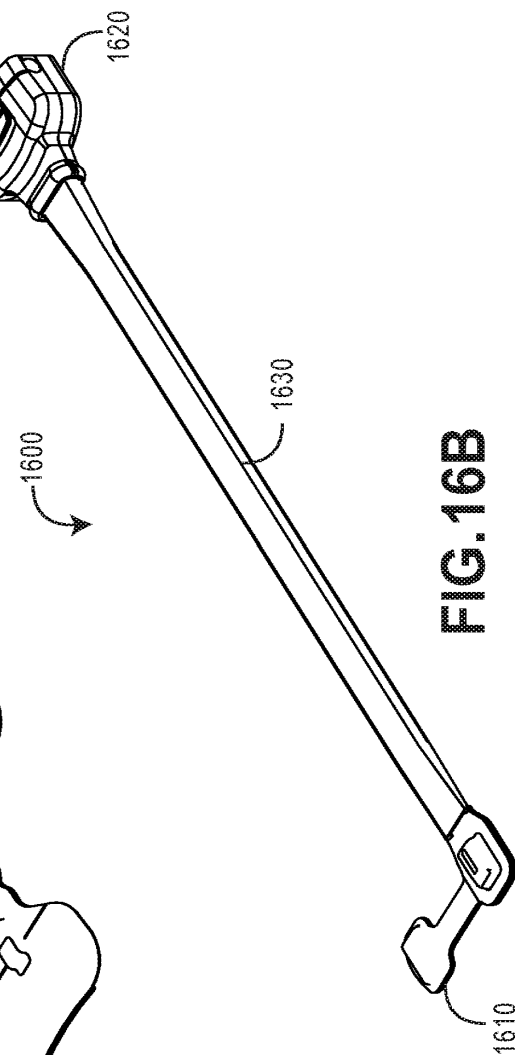
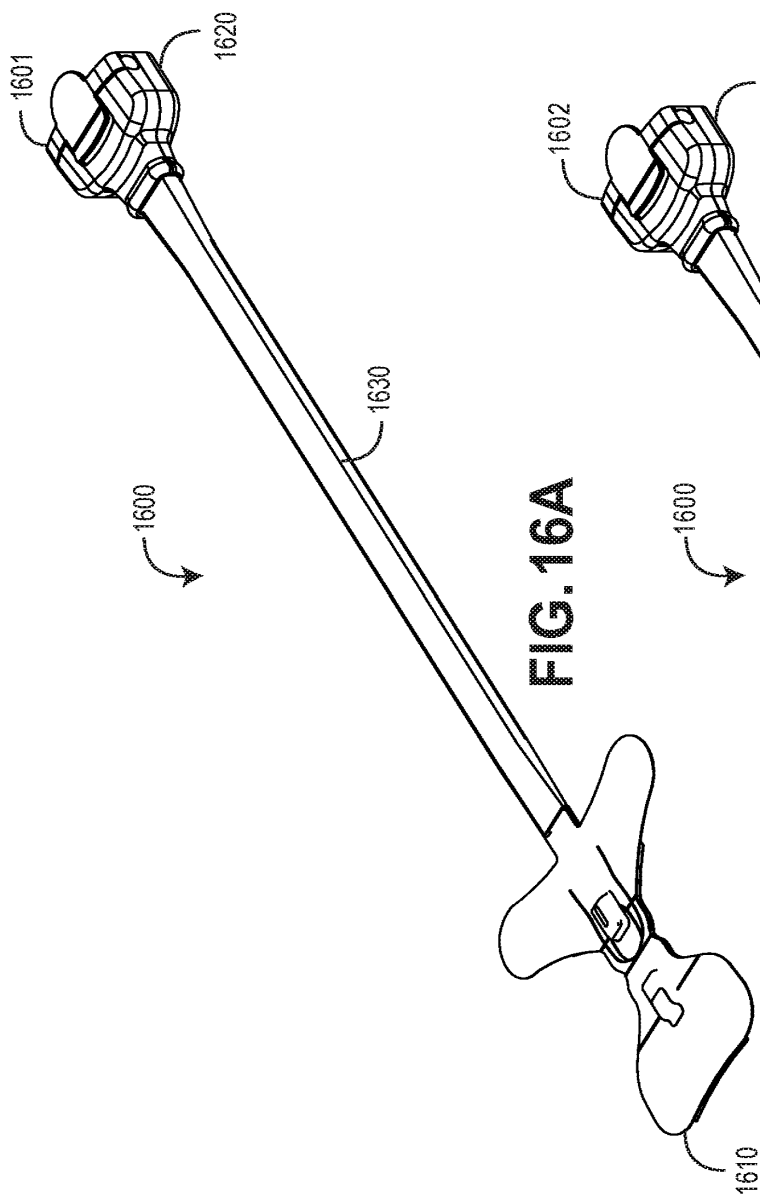
**FIG. 15K (CONT.)**

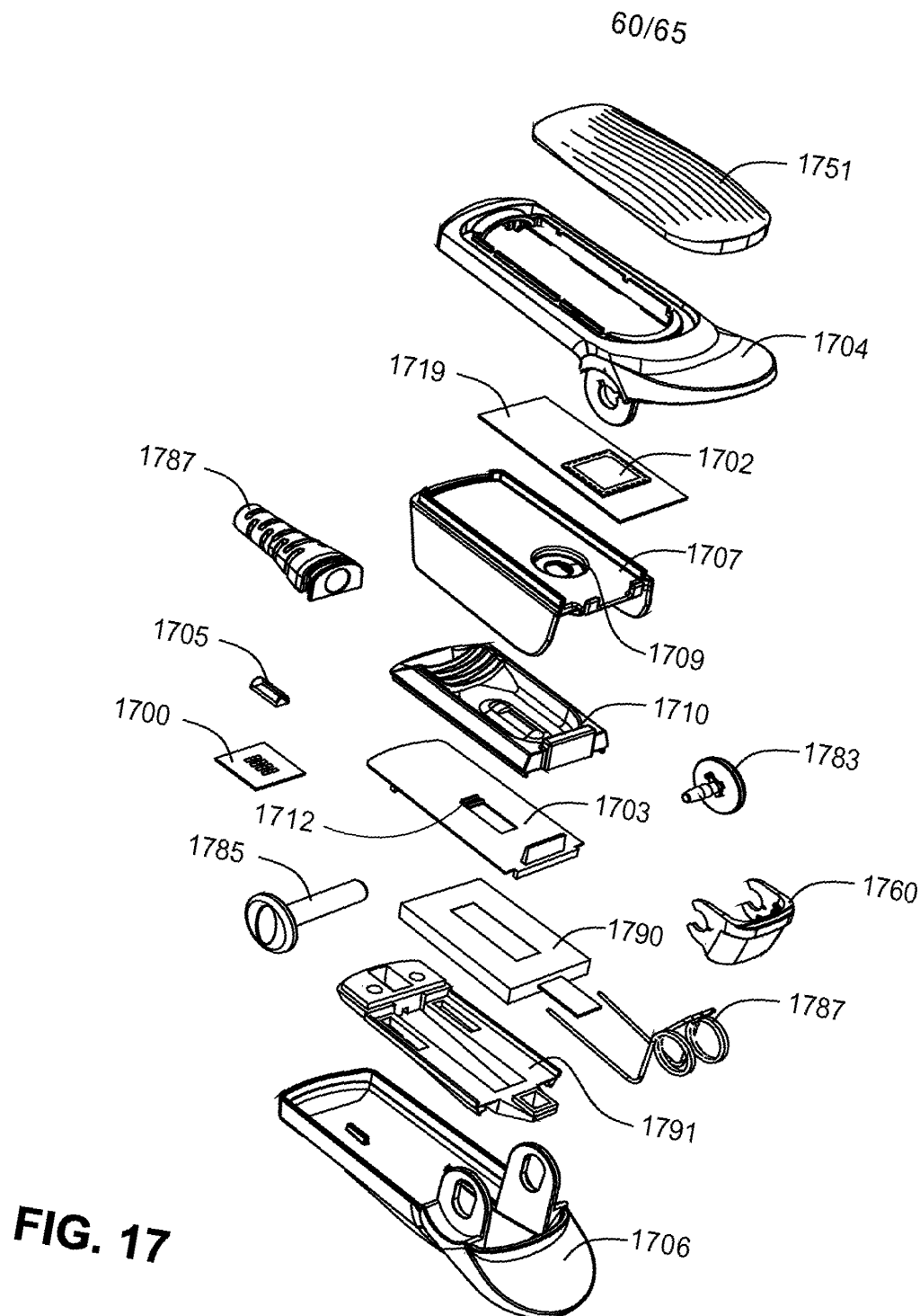
58/65



**FIG. 15L**

59/65

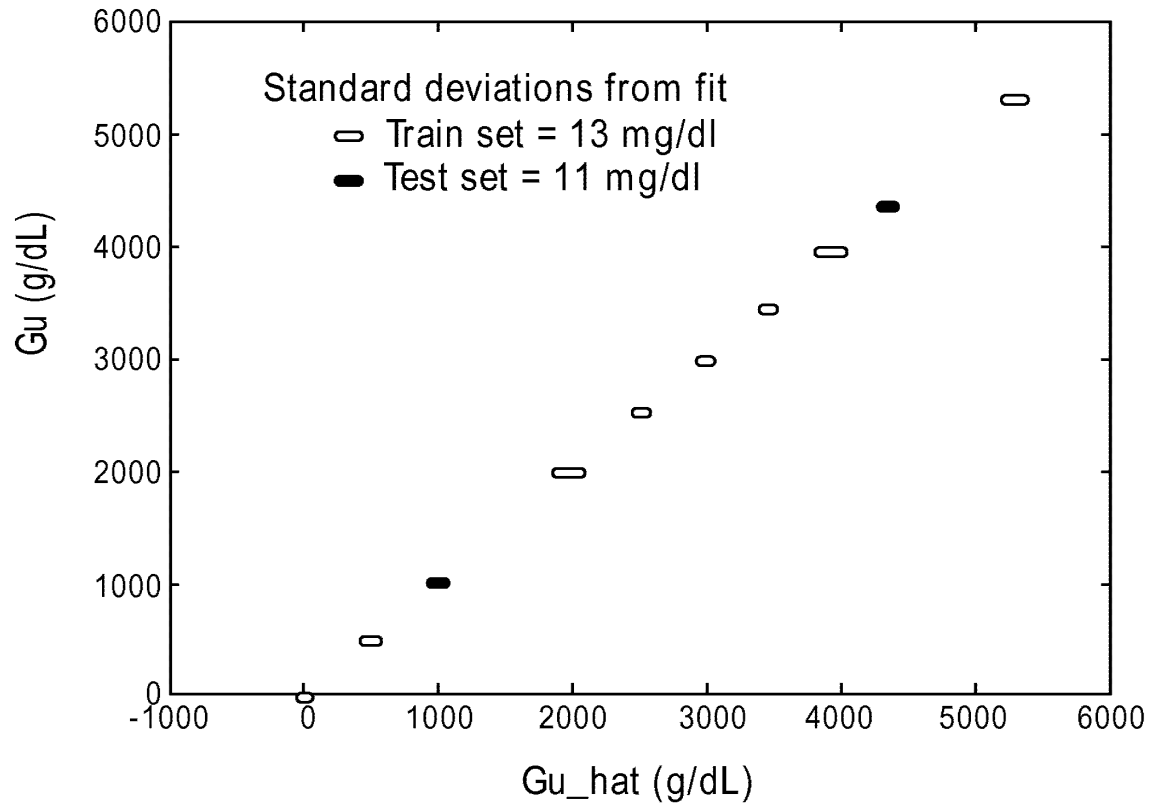




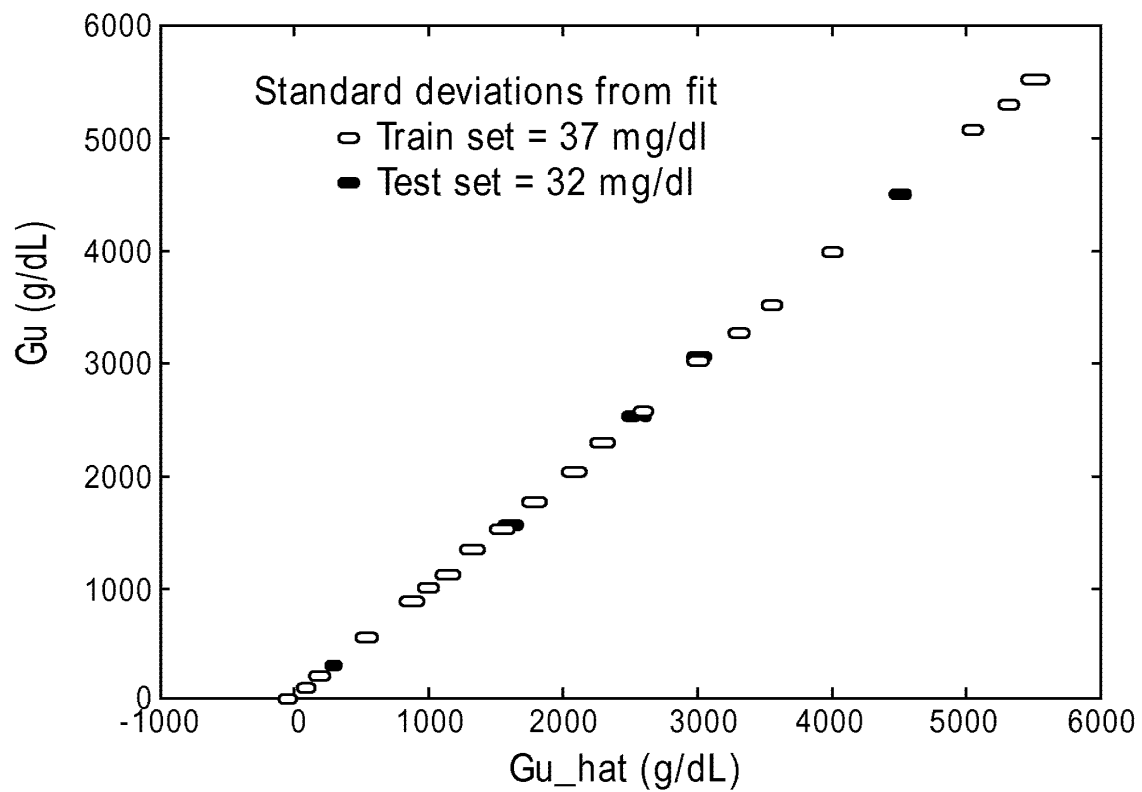
**FIG. 17**



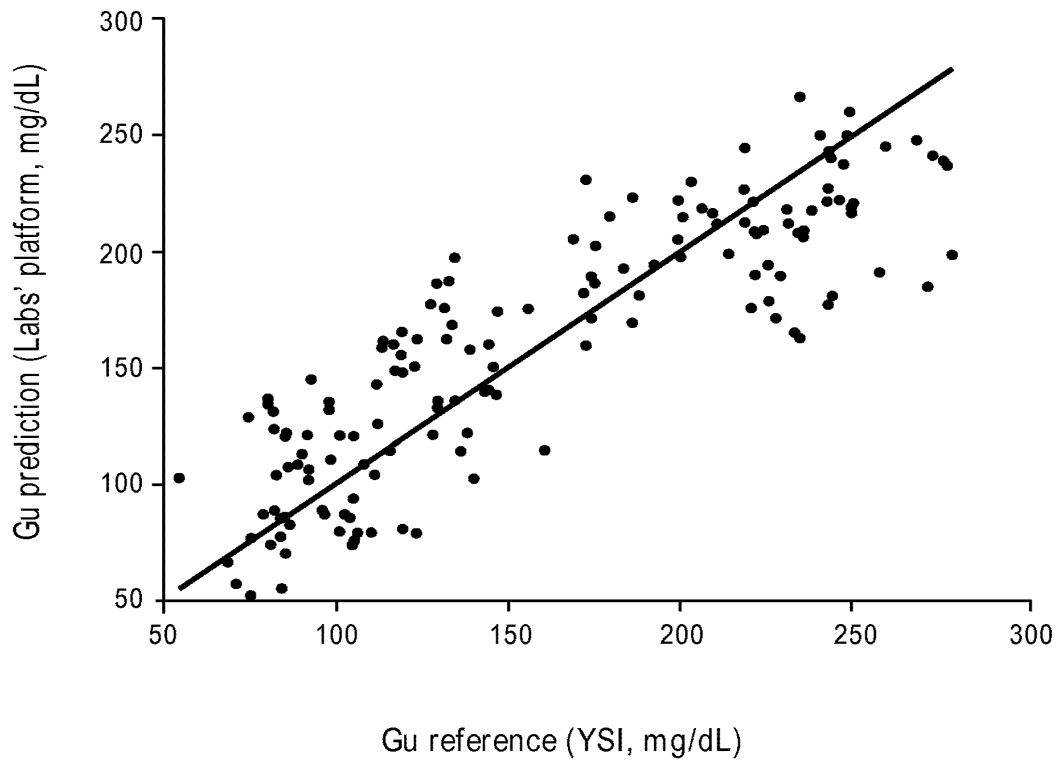
61/65

**FIG. 18**

62/65

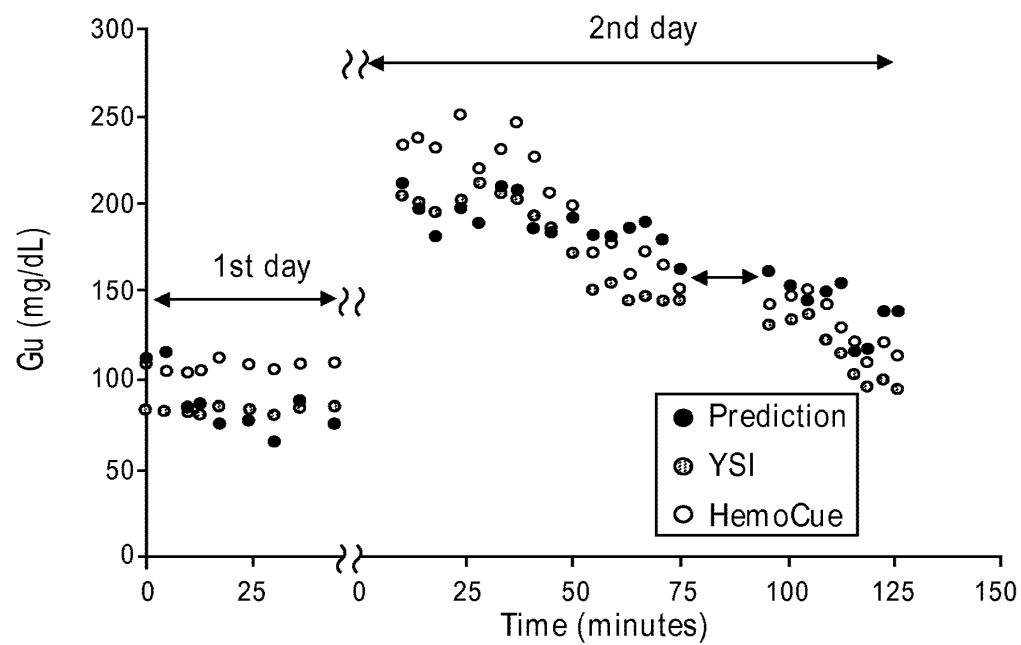
**FIG. 19**

63/65

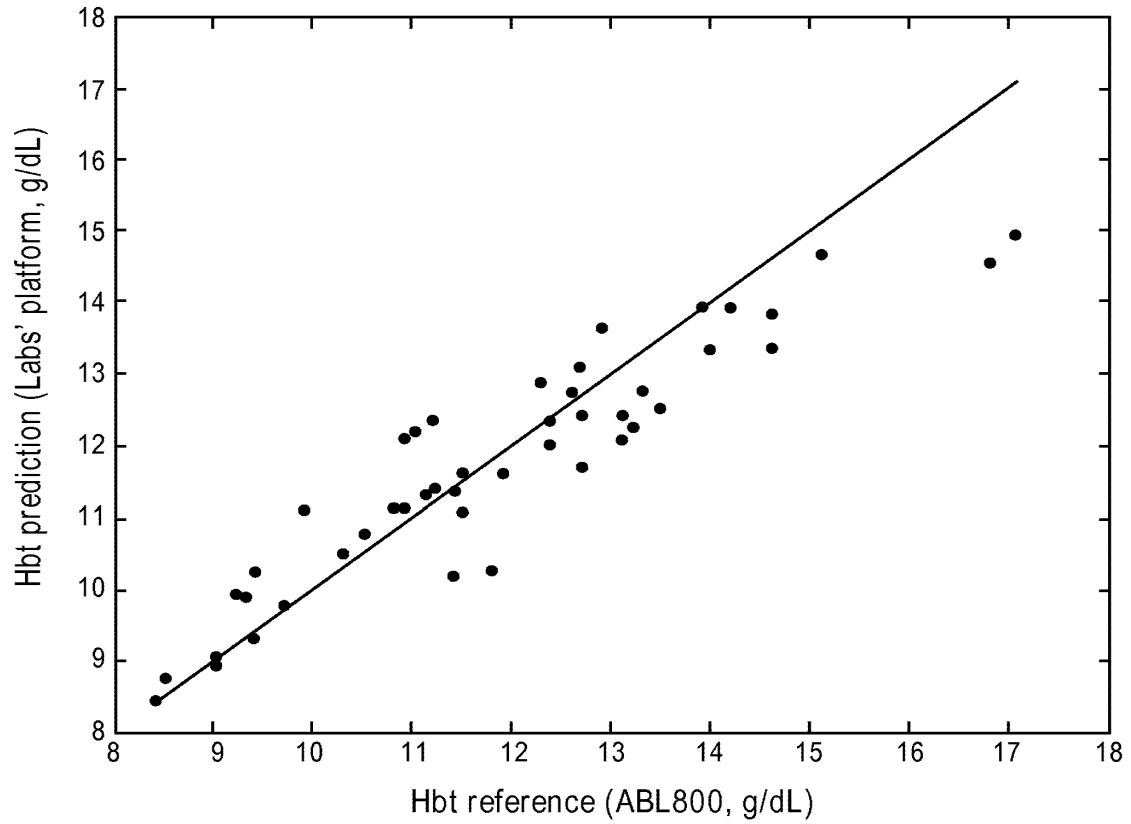


**FIG. 20**

64/65

**FIG. 21**

65/65



**FIG. 22**

Docket No.: MLHUM.002C1

Customer No. 20995

**INFORMATION DISCLOSURE STATEMENT**

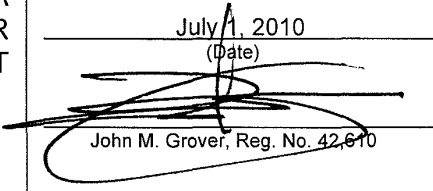
Applicants : Massi Joe E. Kiani et al.  
App. No : Unknown  
Filed : Herewith  
For : MULTI-STREAM DATA  
COLLECTION SYSTEM FOR  
NONINVASIVE MEASUREMENT  
OF BLOOD CONSTITUENTS  
Examiner : Unknown  
Art Unit : Unknown  
Conf No. : Unknown

**CERTIFICATE OF EFS WEB  
TRANSMISSION**

I hereby certify that this correspondence,  
and any other attachment noted on the  
automated Acknowledgement Receipt, is  
being transmitted from within the Pacific  
Time zone to the Commissioner for Patents  
via the EFS Web server on:

July 1, 2010

(Date)

  
John M. Grover, Reg. No. 42,610

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

Enclosed is a PTO/SB/08 Equivalent listing 249 references that are of record in U.S. patent application No. 12/497,528, filed July 2, 2009, which is the parent of this continuation application, and is relied upon for an earlier filing date under 35 U.S.C. § 120. Copies of the references are not submitted pursuant to 37 C.F.R. § 1.98(d).

This Information Disclosure Statement is being filed within three months of the filing date, with an RCE or before receipt of a first office action after an RCE and no fee is required.

The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment, to Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON &amp; BEAR, LLP

Dated: July 1, 2010By: 

John M. Grover  
Registration No. 42,610  
Attorney of Record  
Customer No. 20995  
(949) 760-0404

9288147/070110

Docket No.: MLHUM.002C1

Customer No. 20995

**INFORMATION DISCLOSURE STATEMENT**

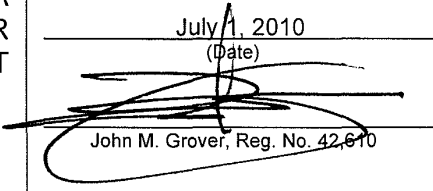
Applicants : Massi Joe E. Kiani et al.  
 App. No : Unknown  
 Filed : Herewith  
 For : MULTI-STREAM DATA  
 COLLECTION SYSTEM FOR  
 NONINVASIVE MEASUREMENT  
 OF BLOOD CONSTITUENTS  
 Examiner : Unknown  
 Art Unit : Unknown  
 Conf No. : Unknown

**CERTIFICATE OF EFS WEB  
TRANSMISSION**

I hereby certify that this correspondence,  
 and any other attachment noted on the  
 automated Acknowledgement Receipt, is  
 being transmitted from within the Pacific  
 Time zone to the Commissioner for Patents  
 via the EFS Web server on:

July 1, 2010

(Date)

  
 John M. Grover, Reg. No. 42,610

Commissioner for Patents  
 P.O. Box 1450  
 Alexandria, VA 22313-1450

Dear Sir:

Enclosed is a PTO/SB/08 Equivalent listing 249 references that are of record in U.S. patent application No. 12/497,528, filed July 2, 2009, which is the parent of this continuation application, and is relied upon for an earlier filing date under 35 U.S.C. § 120. Copies of the references are not submitted pursuant to 37 C.F.R. § 1.98(d).

This Information Disclosure Statement is being filed within three months of the filing date, with an RCE or before receipt of a first office action after an RCE and no fee is required.

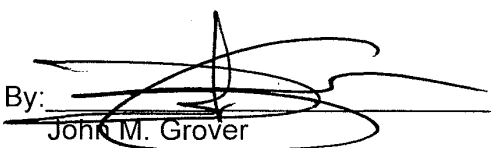
The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment, to Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON &amp; BEAR, LLP

Dated: July 1, 2010

By:

  
 John M. Grover  
 Registration No. 42,610  
 Attorney of Record  
 Customer No. 20995  
 (949) 760-0404

9288147/070110

DocCode - SCORE

## **SCORE Placeholder Sheet for IFW Content**

Application Number: 12829352

Document Date: 7/1/2010

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

- Drawings – Other than Black and White Line Drawings

Since this was an electronic submission, there is no physical artifact folder, no artifact folder is recorded in PALM, and no paper documents or physical media exist. The TIFF images in the IFW record were created from the original documents that are stored in SCORE.

To access the documents in the SCORE database, refer to instructions developed by SIRA.

At the time of document entry (noted above):

- Examiners may access SCORE content via the eDAN interface.
- Other USPTO employees can bookmark the current SCORE URL (<http://es/ScoreAccessWeb/>).
- External customers may access SCORE content via the Public and Private PAIR interfaces.

Form Revision Date: February 8, 2006



CX-1622

Date: 07/01/10

PTO/SB/06 (12-04)

Approved for use through 7/31/2006. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD					Application or Docket Number <b>12/829,352</b>		
Substitute for Form PTO-875							
<b>APPLICATION AS FILED – PART I</b>							
(Column 1)		(Column 2)		SMALL ENTITY		OR	
OTHER THAN SMALL ENTITY							
FOR	NUMBER FILED	NUMBER EXTRA	RATE (\$)	FEE (\$)	RATE (\$)	FEE (\$)	
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A		N/A	330	
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A		N/A	540	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A		N/A	220	
TOTAL CLAIMS (37 CFR 1.16(j))	22	minus 20 = 2	x\$26		x\$52	104	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3	minus 3 = *	x\$110		x\$220		
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$260 (\$130 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR				270		
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			195		390		
			TOTAL		TOTAL	1464	
* If the difference in column 1 is less than zero, enter "0" in column 2.							
<b>APPLICATION AS AMENDED – PART II</b>							
(Column 1)		(Column 2)		(Column 3)			
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	RATE (\$)	ADDITIONAL FEE (\$)
	Total (37 CFR 1.16(i))	Minus **	=	X =		X =	
	Independent (37 CFR 1.16(h))	Minus ***	=	X =		X =	
	Application Size Fee (37 CFR 1.16(s))			N/A		N/A	
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))			TOTAL ADD'T FEE		TOTAL ADD'T FEE	
(Column 1)		(Column 2)		(Column 3)			
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	RATE (\$)	ADDITIONAL FEE (\$)
	Total (37 CFR 1.16(i))	Minus **	=	X =		X =	
	Independent (37 CFR 1.16(h))	Minus ***	=	X =		X =	
	Application Size Fee (37 CFR 1.16(s))			N/A		N/A	
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))			TOTAL ADD'T FEE		TOTAL ADD'T FEE	
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3. ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.							

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 10,335,068 B2  
APPLICATION NO. : 14/981290  
DATED : July 2, 2019  
INVENTOR(S) : Poeze et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page

Item No. (63), Page 2, Column 1 at Lines 3-4, Related U.S. Application Data, Change “12/829,352 is a continuation of application No. 12/497,528” to --12/829,352 is a continuation-in-part of application No. 12/497,528--.

Item No. (63), Page 2, Column 1 at Line 5, Related U.S. Application Data, Change “and a continuation-in-part of” to --which is a continuation-in-part of--.

Item No. (63), Page 2, Column 1 at Lines 9-10, Related U.S. Application Data, Change “12/829,352 is a continuation of application No. 12/497,523” to --12/829,352 is a continuation-in-part of application No. 12/497,523--.

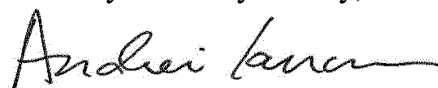
Item No. (63), Page 2, Column 1 at Lines 11-12, Related U.S. Application Data, Change “and a continuation-in-part of” to --which is a continuation-in-part of--.

In the Specification

In Column 1, Lines 16-17, Change “Ser. No. 12/534,827 is also a continuation of” to --Ser. No. 12/829,352 is also a continuation-in-part of--.

In Column 1, Line 29, Change “No. 12/534,827 is also a continuation of” to --No. 12/829,352 is also a continuation-in-part of--.

Signed and Sealed this  
Twenty-first Day of July, 2020



Andrei Iancu  
*Director of the United States Patent and Trademark Office*



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
**United States Patent and Trademark Office**  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/981,290	12/28/2015	Jeroen Poeze	MASCER.002C2	9573

64735	7590	07/09/2020
KNOBBE, MARTENS, OLSON & BEAR, LLP		
MASIMO CORPORATION (MASIMO)		
2040 MAIN STREET		
FOURTEENTH FLOOR		
IRVINE, CA 92614		

EXAMINER	
LIU, CHU CHUAN	

ART UNIT	PAPER NUMBER
3791	

NOTIFICATION DATE	DELIVERY MODE
07/09/2020	ELECTRONIC

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

efiling@knobbe.com  
 jayna.cartee@knobbe.com



UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents  
United States Patent and Trademark Office  
P.O. Box 1450  
Alexandria, VA 22313-1450  
www.uspto.gov

Patent No.: 10335068  
Issue Date: 07/02/2019  
Appl. No.: 14/981,290  
Filed: 12/28/2015

**PART (A) RESPONSE FOR CERTIFICATES OF CORRECTION**

This is a decision on the Certificate of Correction request filed 15 June 2020.

The request for issuance of Certificate of Correction for the above-identified correction(s) under the provisions of 37 CFR 1.322 and/or 1.323 is hereby:

(Check one)

☒ Approved ☐ Approved in Part ☐ Denied

Comments: \_\_\_\_\_

**PART (B) PETITION UNDER 37 CFR 1.324 OR 37 CFR 1.48**

☐ This is a decision on the petition filed \_\_\_\_\_ to correct inventorship under 37 CFR 1.324.

☐ This is a decision on the request under 37 CFR 1.48, petition filed \_\_\_\_\_. In view of the fact that the patent has already issued, the request under 37 CFR 1.48 has been treated as a petition to correct inventorship under 37 CFR 1.324.

The petition is hereby: ☐ Granted ☐ Dismissed

Comment: \_\_\_\_\_

The patented filed is being forwarded to Certificate of Corrections Branch for issuance of a certificate naming only the actual inventor or inventors.

/JACQUELINE CHENG/  
Supervisory Patent Examiner, Art Unit 3791  
Technology Center 3700  
Phone: (571)272-5596

Certificates of Correction Branch email: CustomerServiceCoC@uspto.gov CoC Central Phone Number: (703) 756-1814

Docket No.: MASCER.002C2

Page 1 of 2

**REQUEST FOR CERTIFICATE OF CORRECTION**

First Inventor	:	Jeroen Poeze
App. No.	:	14/981290
Filed	:	December 28, 2015
Patent No.	:	10,335,068
Issue Date	:	July 2, 2019
Title	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Conf. No.	:	9573

Commissioner for Patents  
Office of Data Management  
**Attention:** Certificates of Correction Branch  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Commissioner:

Enclosed for filing is a Certificate of Correction in connection with U.S. Patent No. 10,335,068 ("the Patent"). The desired corrections are set forth on the enclosed form PTO/SB/44 Equivalent, and include corrections to the Title Page of the Patent, and to the first paragraph of the specification of the Patent, to reflect the priority under which the Patent was examined. The initial Filing Receipts dated January 19, 2016 and March 9, 2016 (copies of which are provided as Attachments A and B, respectively), and the Bibliographic Data Sheet signed by the Examiner on February 11, 2019 (a copy of which is provided as Attachment C), properly show the priority as reflected in this Certificate of Correction.

While the priority as reflected in this Certificate of Correction is consistent with that identified in the Filing Receipts and the Bibliographic Data Sheet, in two instances the priority as reflected in this Certificate of Correction differs from what was provided on the Application Data Sheet (a copy of which is provided as Attachment D, including Application Data Sheet filed by the Applicant on December 28, 2015, and the Corrected Application Data Sheet filed by the Applicant on March 13, 2019). These two instances include (i) an identification of the relationship between U.S. Application No. 12/829,352 ("the '352 Application", to which the Patent claims priority) and U.S. Application No. 12/497,528 ("the '528 Application") as a "continuation" instead of as a "continuation-in-part", and (ii) an identification of the relationship between the '352 Application and U.S. Application No. 12/497,523 ("the '523 Application") as a "continuation" instead of as a "continuation-in-part".

Regarding these two instances, MPEP § 1481.03 provides that a Certificate of Correction is the proper procedure to correct an identified relationship between two applications on a patent,

Docket No.: MAS CER.002C2  
App. No.: December 28, 2015

June 15, 2020  
Page 2 of 2

particularly when the correction is to change from an identified “continuation” to an identified “continuation-in-part” relationship. For example, MPEP § 1481.03 provides that,

Where a benefit claim based upon 35 U.S.C. 120, 121, 365(c), or 386(c) is timely submitted, a petition under 37 CFR 1.78(e) is not required for correcting the benefit claim by changing the relationship of the applications (e.g., changing from “continuation” or “divisional” to “continuation-in-part” or from “continuation-in-part” to “continuation” or “divisional”) whether filed during the pendency of the later-filed application or after patent grant.

*See also* MPEP § 211.03 (“A petition under 37 CFR 1.78 and the petition fee would not be required for correcting a timely submitted benefit claim for the following situations: (A) Changing the relationship of the applications (e.g., changing from “continuation” or “divisional” to “continuation-in-part” or from “continuation-in-part” to “continuation” or “divisional”)...”). In the present case, the priority claims to the ’352 Application, and from the ’352 Application to the ’528 and ’523 Applications, were timely submitted, as reflected by the Filing Receipts dated January 19, 2016 and March 9, 2016 (showing that each priority claim was filed within four months from the actual filing date, as required to be considered timely by 37 C.F.R. § 1.78(d)(3)). Accordingly, MPEP § 1481.03 provides that a certificate of correction is proper to reflect the relationship between the ’352 Application and the ’528 Application, and the relationship between the ’352 Application and the ’523 Application as a “continuation-in-part.” Because examination took place based on the priority as reflected in the Filing Receipts and the Bibliographic Data Sheet signed by the Examiner on February 11, 2019 (as also reflected in this Certificate of Correction), no further examination is required.

Some of the errors cited in the Certificate of Correction are the fault of the PTO (see 35 USC § 254, 37 CFR § 1.322, and MPEP § 1480). However, because this may not apply to each item in the Certificate of Correction, the \$150 fee under 37 CFR § 1.20(a) is submitted herewith. Please charge any additional fees to our Deposit Account No. 11 1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: June 15, 2020

By: /Scott Cromar/  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
(949) 760-0404

# UNITED STATES PATENT AND TRADEMARK OFFICE CERTIFICATE OF CORRECTION

**PATENT NO.** : 10,335,068

Page 1 of 1

**APPLICATION NO.** : 14/981290

**ISSUE DATE** : July 2, 2019

**INVENTOR(S)** : Jeroen Poeze

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

Item No. (63), Page 2, Column 1 at Lines 3-4, Related U.S. Application Data, Change “12/829,352 is a continuation of application No. 12/497,528” to --12/829,352 is a continuation-in-part of application No. 12/497,528--.

Item No. (63), Page 2, Column 1 at Line 5, Related U.S. Application Data, Change “and a continuation-in-part of” to --which is a continuation-in-part of--.

Item No. (63), Page 2, Column 1 at Lines 9-10, Related U.S. Application Data, Change “12/829,352 is a continuation of application No. 12/497,523” to --12/829,352 is a continuation-in-part of application No. 12/497,523--.

Item No. (63), Page 2, Column 1 at Lines 11-12, Related U.S. Application Data, Change “and a continuation-in-part of” to --which is a continuation-in-part of--.

In the Specification:

In Column 1, Lines 16-17, Change “Ser. No. 12/534,827 is also a continuation of” to --Ser. No. 12/829,352 is also a continuation-in-part of--.

In Column 1, Line 29, Change “No. 12/534,827 is also a continuation of” to --No. 12/829,352 is also a continuation-in-part of--.

## MAILING ADDRESS OF SENDER:

Scott A. Cromar  
KNOBBE, MARTENS, OLSON & BEAR, LLP  
2040 Main Street, 14<sup>th</sup> Floor  
Irvine, California 92614

DOCKET NO. MASCER.002C1

# **Attachment A**

Copy of 2016-01-19 Filing Receipt





## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO.	TOT CLAIMS	IND CLAIMS
14/981,290	12/28/2015	2688	0.00	MASER.002C2	1	1

CONFIRMATION NO. 9573

## FILING RECEIPT



CC00000079948093

64735  
 KNOBBE, MARTENS, OLSON & BEAR, LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

Date Mailed: 01/19/2016

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

## Inventor(s)

Jeroen Poeze, Rancho Santa Margarita, CA;  
 Marcelo Lamego, Cupertino, CA;  
 Sean Merritt, Lake Forest, CA;  
 Cristiano Dalvi, Lake Forest, CA;  
 Hung Vo, Fountain Valley, CA;  
 Johannes Bruinsma, Opeinde, NETHERLANDS;  
 Ferdyan Lesmana, Irvine, CA;  
 Massi Joe E. Kiani, Laguna Niguel, CA;

## Applicant(s)

MASIMO CORPORATION, Irvine, CA;

**Power of Attorney:** The patent practitioners associated with Customer Number 64735

**Domestic Priority data as claimed by applicant**

This application is a CON of 12/829,352 07/01/2010  
 which is a CON of 12/534,827 08/03/2009 ABN  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and said 12/829,352 07/01/2010  
 is a CIP of 12/497,528 07/02/2009 PAT 8577431  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008

page 1 of 4

and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008 PAT D621516  
 and is a CIP of 29/323,408 08/25/2008 PAT D606659  
 and said 12/829,352 07/01/2010  
 is a CIP of 12/497,523 07/02/2009 PAT 8437825  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008 PAT D621516  
 and is a CIP of 29/323,408 08/25/2008 PAT D606659

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 01/14/2016

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/981,290**

**Projected Publication Date:** To Be Determined - pending completion of Missing Parts

**Non-Publication Request:** No

**Early Publication Request:** No

**Title**

MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

**Preliminary Class**

369

**Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:** No

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international

page 2 of 4

application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

## **LICENSE FOR FOREIGN FILING UNDER**

### **Title 35, United States Code, Section 184**

### **Title 37, Code of Federal Regulations, 5.11 & 5.15**

#### **GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national

security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

**NOT GRANTED**

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

---

***SelectUSA***

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

# **Attachment B**

Copy of 2016-03-09 Filing Receipt



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
14/981,290	12/28/2015	2688	1740	MASER.002C2	18	3

CONFIRMATION NO. 9573

## UPDATED FILING RECEIPT



CC00000081288622

64735  
 KNOBBE, MARTENS, OLSON & BEAR, LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

Date Mailed: 03/09/2016

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

## Inventor(s)

Jeroen Poeze, Rancho Santa Margarita, CA;  
 Marcelo Lamego, Cupertino, CA;  
 Sean Merritt, Lake Forest, CA;  
 Cristiano Dalvi, Lake Forest, CA;  
 Hung Vo, Fountain Valley, CA;  
 Johannes Bruinsma, Opeinde, NETHERLANDS;  
 Ferdyan Lesmana, Irvine, CA;  
 Massi Joe E. Kiani, Laguna Niguel, CA;

## Applicant(s)

MASIMO CORPORATION, Irvine, CA;

**Power of Attorney:** The patent practitioners associated with Customer Number 64735

**Domestic Priority data as claimed by applicant**

This application is a CON of 12/829,352 07/01/2010 PAT 9277880  
 which is a CON of 12/534,827 08/03/2009 ABN  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and said 12/829,352 07/01/2010  
 is a CIP of 12/497,528 07/02/2009 PAT 8577431  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008

page 1 of 4

and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008 PAT D621516  
 and is a CIP of 29/323,408 08/25/2008 PAT D606659  
 and said 12/829,352 07/01/2010  
 is a CIP of 12/497,523 07/02/2009 PAT 8437825  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008 PAT D621516  
 and is a CIP of 29/323,408 08/25/2008 PAT D606659

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 01/14/2016

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/981,290**

**Projected Publication Date:** 06/16/2016

**Non-Publication Request:** No

**Early Publication Request:** No

**Title**

MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

**Preliminary Class**

369

**Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:** No

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international

page 2 of 4

application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

## **LICENSE FOR FOREIGN FILING UNDER**

### **Title 35, United States Code, Section 184**

### **Title 37, Code of Federal Regulations, 5.11 & 5.15**

#### **GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national



security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

**NOT GRANTED**

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

---

***SelectUSA***

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

## **Attachment C**

Copy of 2019-02-11 Bibliographic Data Sheet

**Bibliographic Data**

Application No: 14/981,290

Foreign Priority claimed: ☐ Yes ☒ No35 USC 119 (a-d) conditions met: ☐ Yes ☒ No ☐ Met After Allowance

Verified and Acknowledged:

/CHU CHUAN LIU/

Examiner's Signature

Initials

Title:

MULTI-STREAM DATA COLLECTION SYSTEM FOR  
NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

---

<b>FILING or 371(c) DATE</b>	<b>CLASS</b>	<b>GROUP ART UNIT</b>	<b>ATTORNEY DOCKET NO.</b>
12/28/2015	600	3791	MASCER.002C2
<b>RULE</b>			

**APPLICANTS**

MASIMO CORPORATION, Irvine, CA, UNITED STATES

**INVENTORS**

Jeroen Poeze Rancho Santa Margarita, CA, UNITED STATES

Marcelo Lamago Cupertino, CA, UNITED STATES

Sean Merritt Lake Forest, CA, UNITED STATES

Cristiano Dalvi Lake Forest, CA, UNITED STATES

Hung Vo Fountain Valley, CA, UNITED STATES

Johannes Bruinsma Opeinde, NETHERLANDS

Ferdyan Lesmana Irvine, CA, UNITED STATES

Massi Joe E. Kiani Laguna Niguel, CA, UNITED STATES

**CONTINUING DATA**

This application is a CON of 12829352 07/01/2010 PAT 9277880

12829352 is a CON of 12534827 08/03/2009ABN

12829352 is a CIP of 12497523 07/02/2009 PAT 8437825

12829352 is a CIP of 12497528 07/02/2009 PAT 8577431

12497528 is a CIP of 29323409 08/25/2008 PAT D621516

12497523 is a CIP of 29323408 08/25/2008 PAT D606659

12497523 is a CIP of 29323409 08/25/2008 PAT D621516

12534827 has PRO of 61091732 08/25/2008

12497528 has PRO of 61091732 08/25/2008

12497523 has PRO of 61091732 08/25/2008

12497528 is a CIP of 29323408 08/25/2008 PAT D606659

12497523 has PRO of 61086060 08/04/2008  
12497528 has PRO of 61086057 08/04/2008  
12534827 has PRO of 61086108 08/04/2008  
12497523 has PRO of 61086057 08/04/2008  
12497523 has PRO of 61086063 08/04/2008  
12497528 has PRO of 61086063 08/04/2008  
12497523 has PRO of 61086108 08/04/2008  
12497528 has PRO of 61086108 08/04/2008  
12497528 has PRO of 61086060 08/04/2008  
12534827 has PRO of 61086057 08/04/2008  
12534827 has PRO of 61086060 08/04/2008  
12534827 has PRO of 61086063 08/04/2008  
12497528 has PRO of 61078228 07/03/2008  
12497523 has PRO of 61078228 07/03/2008  
12497528 has PRO of 61078207 07/03/2008  
12497523 has PRO of 61078207 07/03/2008

**FOREIGN APPLICATIONS**

**IF REQUIRED, FOREIGN LICENSE GRANTED\*\***

01/14/2016

**STATE OR COUNTRY**

UNITED STATES

**ADDRESS**

KNOBBE, MARTENS, OLSON & BEAR, LLP  
MASIMO CORPORATION (MASIMO)  
2040 MAIN STREET  
FOURTEENTH FLOOR  
IRVINE, CA 92614  
UNITED STATES

**FILING FEE RECEIVED**

\$1,740

## **Attachment D**

Copy of 2015-12-28 Application Data Sheet  
and  
Copy of 2019-03-13 Corrected Application Data Sheet

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
<p>The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.</p> <p>This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.</p>			

**Secrecy Order 37 CFR 5.2:**

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

**Inventor Information:**

<b>Inventor 1</b>					<a href="#">Remove</a>	
<b>Legal Name</b>						
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>		
	Jeroen		Poeze			
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service						
<b>City</b>	Rancho Santa Margarita	<b>State/Province</b>	CA	<b>Country of Residence</b>	US	
<b>Mailing Address of Inventor:</b>						
<b>Address 1</b>	53 Tierra Seguro					
<b>Address 2</b>						
<b>City</b>	Rancho Santa Margarita	<b>State/Province</b>	CA			
<b>Postal Code</b>	92688	<b>Country</b>	US			
<b>Inventor 2</b>					<a href="#">Remove</a>	
<b>Legal Name</b>						
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>		
	Marcelo		Lamego			
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service						
<b>City</b>	Cupertino	<b>State/Province</b>	CA	<b>Country of Residence</b>	US	
<b>Mailing Address of Inventor:</b>						
<b>Address 1</b>	10292 Orange Avenue					
<b>Address 2</b>						
<b>City</b>	Cupertino	<b>State/Province</b>	CA			
<b>Postal Code</b>	95014	<b>Country</b>	US			
<b>Inventor 3</b>					<a href="#">Remove</a>	
<b>Legal Name</b>						
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>		
	Sean		Merritt			
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service						

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number		MASCER.002C2	
		Application Number			
Title of Invention		MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS			
City	Lake Forest	State/Province	CA	Country of Residence	US
<b>Mailing Address of Inventor:</b>					
Address 1		25111 Paseo Arboleda			
Address 2					
City	Lake Forest	State/Province	CA		
Postal Code	92630	Country	US		
Inventor 4					<a href="#">Remove</a>
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Cristiano		Dalvi		
Residence Information (Select One) <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Lake Forest	State/Province	CA	Country of Residence	US
<b>Mailing Address of Inventor:</b>					
Address 1		23972 Oswego St.			
Address 2					
City	Lake Forest	State/Province	CA		
Postal Code	92630	Country	US		
Inventor 5					<a href="#">Remove</a>
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Hung		Vo		
Residence Information (Select One) <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Fountain Valley	State/Province	CA	Country of Residence	US
<b>Mailing Address of Inventor:</b>					
Address 1		18849 Teton Cir.			
Address 2					
City	Fountain Valley	State/Province	CA		
Postal Code	92708	Country	US		
Inventor 6					<a href="#">Remove</a>
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Johannes		Bruinsma		
Residence Information (Select One) <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number		MASCER.002C2	
		Application Number			
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS				

City	Opeinde	Country of Residence <sup>i</sup>	NL		
------	---------	-----------------------------------	----	--	--

  
**Mailing Address of Inventor:**

Address 1	Teije Blauwsingel 45				
Address 2					
City	9218 RT Opeinde	State/Province			
Postal Code		Country <sup>i</sup>	NL		
Inventor 7	<a href="#">Remove</a>				
<b>Legal Name</b>					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Ferdyan		Lesmana		
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Irvine	State/Province	CA	Country of Residence <sup>i</sup>	US

  
**Mailing Address of Inventor:**

Address 1	42 New Season				
Address 2					
City	Irvine	State/Province	CA		
Postal Code	92602	Country <sup>i</sup>	US		
Inventor 8	<a href="#">Remove</a>				
<b>Legal Name</b>					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Massi	Joe E.	Kiani		
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Laguna Niguel	State/Province	CA	Country of Residence <sup>i</sup>	US

  
**Mailing Address of Inventor:**

Address 1	1 Point Catalina				
Address 2					
City	Laguna Niguel	State/Province	CA		
Postal Code	92677	Country <sup>i</sup>	US		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the <b>Add</b> button. <span style="float: right;"><a href="#">Add</a></span>					

**Correspondence Information:**

Enter either Customer Number or complete the Correspondence Information section below.  
For further information see 37 CFR 1.33(a).



<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
<input type="checkbox"/> An Address is being provided for the correspondence information of this application.			
Customer Number	64735		
Email Address	efiling@knobbe.com	<input type="button" value="Add Email"/>	<input type="button" value="Remove Email"/>

**Application Information:**

Title of the Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
Attorney Docket Number	MASCER.002C2	Small Entity Status Claimed	<input type="checkbox"/>
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	65	Suggested Figure for Publication (if any)	

**Filing By Reference:**

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

**Publication Information:**

<input type="checkbox"/> Request Early Publication (Fee required at time of Request 37 CFR 1.219)
<input type="checkbox"/> <b>Request Not to Publish.</b> I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application <b>has not and will not</b> be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

**Representative Information:**

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.			
Please Select One:	<input checked="" type="radio"/> Customer Number	<input type="radio"/> US Patent Practitioner	<input type="radio"/> Limited Recognition (37 CFR 11.9)
Customer Number	64735		

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

**Domestic Benefit/National Stage Information:**

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
	Continuation of	12/829352	2010-07-01		
Prior Application Status	Abandoned	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/829352	Continuation of	12/534827	2009-08-03		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/086060	2008-08-04		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/086108	2008-08-04		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/086063	2008-08-04		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/086057	2008-08-04		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/091732	2008-08-25		
Prior Application Status	Patented	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/829352	Continuation of	12/497528	2009-07-02	8577431	2013-11-03

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/086060	2008-08-04		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/086108	2008-08-04		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/086063	2008-08-04		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/086057	2008-08-04		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/078228	2008-07-03		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/078207	2008-07-03		
Prior Application Status	Expired	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/091732	2008-08-25		
Prior Application Status	Patented	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/497528	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10
Prior Application Status	Patented	<a href="#">Remove</a>			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/497528	Continuation in part of	29/323408	2008-08-25	D606659	2009-12-22

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

Prior Application Status		Patented		<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/829352	Continuation of	12/497523	2009-07-02	8437825	2013-05-07
Prior Application Status		Expired		<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497523	Claims benefit of provisional	61/086060	2008-08-04		
Prior Application Status		Expired		<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497523	Claims benefit of provisional	61/086108	2008-08-04		
Prior Application Status		Expired		<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497523	Claims benefit of provisional	61/086063	2008-08-04		
Prior Application Status		Expired		<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497523	Claims benefit of provisional	61/086057	2008-08-04		
Prior Application Status				<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497523	Claims benefit of provisional	61/078228	2008-07-03		
Prior Application Status		Expired		<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497523	Claims benefit of provisional	61/078207	2008-07-03		
Prior Application Status		Expired		<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497523	Claims benefit of provisional	61/091732	2008-08-25		
Prior Application Status		Patented		<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/497523	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number		MASCER.002C2	
		Application Number			
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS				
Prior Application Status		Patented		<a href="#">Remove</a>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/497523	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the <b>Add</b> button.					

### Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)<sup>i</sup> the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

		<a href="#">Remove</a>	
Application Number	Country <sup>i</sup>	Filing Date (YYYY-MM-DD)	Access Code <sup>i</sup> (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the <b>Add</b> button.			

### Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

<input type="checkbox"/> This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.
---

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

## Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

**NOTE:** This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

### 1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

**A. Priority Document Exchange (PDX)** - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

**B. Search Results from U.S. Application to EPO** - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

### 2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

**NOTE:** Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

**Applicant Information:**

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.			
<b>Applicant 1</b>			
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.			
<input type="button" value="Clear"/>			
<input checked="" type="radio"/> Assignee	<input type="radio"/> Legal Representative under 35 U.S.C. 117	<input type="radio"/> Joint Inventor	
<input type="radio"/> Person to whom the inventor is obligated to assign.		<input type="radio"/> Person who shows sufficient proprietary interest	
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:			
Name of the Deceased or Legally Incapacitated Inventor: <input type="text"/>			
If the Applicant is an Organization check here. <input checked="" type="checkbox"/>			
Organization Name	MASIMO CORPORATION		
<b>Mailing Address Information For Applicant:</b>			
Address 1	52 Discovery		
Address 2			
City	Irvine	State/Province	CA
Country	US	Postal Code	92618
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button.			

**Assignee Information including Non-Applicant Assignee Information:**

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.
---

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

<b>Assignee 1</b>				
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
If the Assignee or Non-Applicant Assignee is an Organization check here. <input type="checkbox"/>				
Prefix	Given Name	Middle Name	Family Name	Suffix
<b>Mailing Address Information For Assignee including Non-Applicant Assignee:</b>				
Address 1				
Address 2				
City		State/Province		
Country <sup>i</sup>		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.				

**Signature:**

**NOTE:** This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

<b>Signature</b>	/Scott Cromar/		Date (YYYY-MM-DD)	2015-12-28
First Name	Scott	Last Name	Cromar	Registration Number
65066				
Additional Signature may be generated within this form by selecting the Add button.				



PTO/AIA/14 (11-15)  
CX1623

Approved for use through 04/30/2017. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

## Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Docket Number: MASCER.002C2

**APPLICATION DATA SHEET****Application Information**

Application Number: 14/981290  
 Filing Date: December 28, 2015  
 Application Type: Nonprovisional  
 Subject Matter: Utility  
 Title: MULTI-STREAM DATA COLLECTION SYSTEM FOR  
 NONINVASIVE MEASUREMENT OF BLOOD  
 CONSTITUENTS  
 Attorney Docket Number: MASCER.002C2

**Domestic Priority Information**

Prior Application Status		Pending <u>Patented</u>			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
This Application	Continuation of	12/829352	2010-07-01	<u>9277880</u>	<u>2016-03-08</u>

Prior Application Status		Abandoned			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:		
12/829352	Continuation of	12/534827	2009-08-03		

Prior Application Status		Expired			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:		
12/534827	Claims benefit of provisional	61/086060	2008-08-04		

Prior Application Status		Expired			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:		
12/534827	Claims benefit of provisional	61/086108	2008-08-04		

Prior Application Status		Expired			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:		
12/534827	Claims benefit of provisional	61/086063	2008-08-04		

1

14/981290

Filed: December 28, 2015

Docket Number: MASCER.002C2

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/534827	Claims benefit of provisional	61/086057	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/534827	Claims benefit of provisional	61/091732	2008-08-25

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/829352	Continuation of	12/497528	2009-07-02	8577431	2013-11-03

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/086060	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/086108	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/086063	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/086057	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/078228	2008-07-03

Docket Number: MASCER.002C2

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/078207	2008-07-03

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/091732	2008-08-25

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/497528	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/497528	Continuation in part of	29/323408	2008-08-25	D606659	2009-12-22

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/829352	Continuation of	12/497523	2009-07-02	8437825	2013-05-07

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/086060	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/086108	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/086063	2008-08-04

Docket Number: MASCER.002C2

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/086057	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/078228	2008-07-03

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/078207	2008-07-03

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/091732	2008-08-25

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/497523	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/497523	Continuation in part of	<del>29/323409</del>	2008-08-25	<del>D621516</del>	<del>2010-08-10</del>
		<u>29/323408</u>		<u>D606659</u>	<u>2009-12-22</u>

**Correspondence Information**

Correspondence Customer Number: 64735

E-Mail Address: efiling@knobbe.com

Dated: March 13, 2019

By: /Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
Customer No. 64735  
(949) 760-0404

30118155

Electronic Patent Application Fee Transmittal				
<b>Application Number:</b>	14981290			
<b>Filing Date:</b>	28-Dec-2015			
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS			
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze			
<b>Filer:</b>	Scott Cromar/Frances Tsai			
<b>Attorney Docket Number:</b>	MASCER.002C2			
Filed as Large Entity				
<b>Filing Fees for Utility under 35 USC 111(a)</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent-Appeals-and-Interference:</b>				
<b>Post-Allowance-and-Post-Issuance:</b>				
CERTIFICATE OF CORRECTION	1811	1	150	150



CX-1623

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				150

CX-1623

<b>Electronic Acknowledgement Receipt</b>	
<b>EFS ID:</b>	39717919
<b>Application Number:</b>	14981290
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9573
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	64735
<b>Filer:</b>	Scott Cromar/Jim Nyenhuis
<b>Filer Authorized By:</b>	Scott Cromar
<b>Attorney Docket Number:</b>	MASCER.002C2
<b>Receipt Date:</b>	15-JUN-2020
<b>Filing Date:</b>	28-DEC-2015
<b>Time Stamp:</b>	14:34:36
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$150
RAM confirmation Number	E20206EE35073675
Deposit Account	111410
Authorized User	Jim Nyenhuis
<p>The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:</p> <p>37 CFR 1.17 (Patent application and reexamination processing fees)</p> <p>37 CFR 1.16 (National application filing, search, and examination fees)</p>	

Page 41 of 643

**Appx59401**

CX-1623

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Certificate of Correction	CoC_C2.pdf	762191 f8004a68657c21fb95fbb3fd605280a5b91d0482	no	35
2	Fee Worksheet (SB06)	fee-info.pdf	30078 2012583a8c14c455707e440d157e46daf19ab07b	no	2
<b>Warnings:</b>					
<b>Information:</b>					
<b>Total Files Size (in bytes):</b>			792269		
<p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>  If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>  If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>  If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p>					



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/981,290	07/02/2019	10335068	MASCER.002C2	9573

64735 7590 06/12/2019

KNOBBE, MARTENS, OLSON & BEAR, LLP  
 MASIMO CORPORATION (MASIMO)  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

**ISSUE NOTIFICATION**

The projected patent number and issue date are specified above.

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**

(application filed on or after May 29, 2000)

The Patent Term Adjustment is 509 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

Jeroen Poeze, Rancho Santa Margarita, CA;  
 MASIMO CORPORATION, Irvine, CA;  
 Marcelo Lamego, Cupertino, CA;  
 Sean Merritt, Lake Forest, CA;  
 Cristiano Dalvi, Lake Forest, CA;  
 Hung Vo, Fountain Valley, CA;  
 Johannes Bruinsma, Opeinde, NETHERLANDS;  
 Ferdyan Lesmana, Irvine, CA;  
 Massi Joe E. Kiani, Laguna Niguel, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit [SelectUSA.gov](http://SelectUSA.gov).

CX-1623

**PART B - FEE(S) TRANSMITTAL**

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

64735 7590 02/11/2019  
KNOBBE, MARTENS, OLSON & BEAR, LLP  
MASIMO CORPORATION (MASIMO)  
2040 MAIN STREET  
FOURTEENTH FLOOR  
IRVINE, CA 92614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/981,290	12/28/2015	Jeroen Poeze	MASCER.002C2	9573

TITLE OF INVENTION: MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	05/13/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
LIU, CHU CHUAN	3791	600-322000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Knobbe Martens

2 Olson &amp; Bear LLP

3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

MASIMO CORPORATION

Irvine, CA

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies \_\_\_\_\_

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 11-1410

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29☐ Applicant asserting small entity status. See 37 CFR 1.27☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Scott Cromar/

Date 2019-05-10

Typed or printed name Scott Cromar

Registration No. 65066

Docket No.: MASCER.002C2

PATENT

Please Direct All Correspondence to Customer Number 64735

---

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

First Inventor	:	Jeroen Poeze
App. No.	:	14/981,290
Filed	:	December 28, 2015
For	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner	:	Liu, Chu Chuan
Art Unit	:	3791
Conf. No.	:	9573

**COMMENTS ON EXAMINER'S STATEMENT OF REASONS FOR ALLOWANCE**

**Mail Stop Issue Fee**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Commissioner:

In response to the Examiner's Statement of Reasons for Allowance mailed on February 11, 2019, Applicant respectfully submits the following comments.

Applicant acknowledges the Examiner's statement regarding Allowable Subject Matter and agrees that the claimed subject matter is patentable. To the extent that there is any implication that the patentability of the claims rests on the recitation of a single feature, Applicant respectfully disagrees with the Examiner's Statement because it is the combination of features that makes the claims patentable. Accordingly, Applicant submits that the claims of the present application are allowable because each of the claims recites a combination of features that are not taught or suggested by the prior art. Applicant takes no other positions regarding the Allowable Subject Matter presented by the Examiner other than the positions Applicant may have previously taken during prosecution. Therefore, the Examiner's statement regarding Allowable Subject Matter should not be attributed to Applicant as an indication of the basis for Applicant's belief that the claims are patentable. Furthermore, Applicant respectfully asserts that

Docket No.: MASCER.002C2  
App. No.: 14/981290

May 10, 2019  
Page 2 of 5

there may also be additional reasons for patentability of the claimed subject matter not explicitly stated in this record and Applicant does not waive rights to such arguments by not further addressing such reasons herein.

To the extent that there is any implication that the patentability of dependent claims is only attributable to the limitations in the independent claim from which each depends or that the dependent claims have the same scope as the claims from which they depend, Applicant respectfully disagrees and notes that it is each claim, taken as a whole, that is patentable. For dependent claims, their additional limitations may also provide additional reasons for patentability. Accordingly, Applicant submits that each of the allowed claims is allowable because the prior art does not teach or suggest the combination of features

Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the application's disclosure. Accordingly, reviewers of this or any child or related prosecution history shall not reasonably infer that the Applicant has made any disclaimers, disavowals, or abandonments of any subject matter supported by the present application, and any prior or alleged disclaimers, disavowals, or abandonments are hereby rescinded.

#### References for Examiner Consideration

Applicant wishes to draw the Examiner's attention to, and encourages the Examiner to review, the following co-owned patents and/or applications and their existing and ongoing prosecution history, including without limitation Office Actions, Amendments, Remarks, and any other potentially relevant documents:

Docket No.	Patent No.	Title	Issued
MASCER.002C1	9,277,880	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	03/08/2016
MASCER.002C3	10,258,265	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	04/16/2019
MASCER.002C4	10,258,266	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	04/16/2019

Docket No.: MASCER.002C2  
App. No.: 14/981290

May 10, 2019  
Page 3 of 5

Docket No.	Patent No.	Title	Issued
MASCER.003A	8,630,691	MULTI-STREAM SENSOR FRONT ENDS FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	01/14/2014
MASCER.003D1	8,909,310	MULTI-STREAM SENSOR FRONT ENDS FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	12/09/2014
MASCER.004A	8,203,704	MULTI-STREAM SENSOR FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	06/19/2012
MASCER.004C1	8,570,503	HEAT SINK FOR NONINVASIVE MEDICAL SENSOR	10/29/2013
CERCA.005A	8,515,509	MULTI-STREAM EMITTER FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	08/20/2013
MASCER.006A	8,577,431	NOISE SHIELDING FOR A NONINVASIVE DEVICE	11/05/2013
MASCER.006C1	9,717,425	NOISE SHIELDING FOR A NONINVASIVE DEVICE	08/01/2017
MASCER.007A	8,437,825	CONTOURED PROTRUSION FOR IMPROVING SPECTROSCOPIC MEASUREMENT OF BLOOD CONSTITUENTS	05/07/2013
MASCER.007C1	9,591,975	CONTOURED PROTRUSION FOR IMPROVING SPECTROSCOPIC MEASUREMENT OF BLOOD CONSTITUENTS	03/14/2017
MASCER.008A	8,688,183	EMITTER DRIVER FOR NONINVASIVE PATIENT MONITOR	04/01/2014
MASCER.008C1	9,186,102	EMITTER DRIVER FOR NONINVASIVE PATIENT MONITOR	11/17/2015
MASCER.008C2	9,668,680	EMITTER DRIVER FOR NONINVASIVE PATIENT MONITOR	06/06/2017
MASCER.009DA	D621516	PATIENT MONITORING SENSOR	08/10/2010
MASCER.010DA	D606659	PATIENT MONITOR	12/22/2009

Docket No.	Serial No.	Title	Filed
MASCER.002A	12/534827	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	08/03/2009



Docket No.: MASCER.002C2  
App. No.: 14/981290

May 10, 2019  
Page 4 of 5

<b>Docket No.</b>	<b>Serial No.</b>	<b>Title</b>	<b>Filed</b>
MASCER.002C5	16/261366	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	01/29/2019
MASCER.002C6	16/261326	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	01/29/2019
MASCER.004C3	14/064055	MULTI-STREAM SENSOR FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS	10/25/2013
MASCER.006C2	15/660743	NOISE SHIELDING FOR A NONINVASIVE DEVICE	07/26/2017
MASCER.008C3	15/615671	EMITTER DRIVER FOR NONINVASIVE PATIENT MONITOR	06/06/2017
MASCER.011A	12/497506	HEAT SINK FOR NONINVASIVE MEDICAL SENSOR	07/02/2009

Applicant notes that cited references, office actions, responses, and notices of allowance currently exist or will exist with reference to the above-referenced matters. Applicant also understands that the Examiner has access to sophisticated online Patent Office computing systems that provide ready access to the full file histories of these matters including, for example, specifications, drawings, pending claims, cited art, office actions, responses, declarations, and notices of allowance. Rather than submit copies of these file histories, Applicant respectfully requests that the Examiner continue to review these file histories online for past, current, and future information about these matters that may be relevant to examination of the present application. Also, if the Examiner cannot readily access these file histories, Applicant would be pleased to provide any portion of any of the file histories at any time upon specific Examiner request.

CX-1623

Docket No.: MASCER.002C2  
App. No.: 14/981290

May 10, 2019  
Page 5 of 5

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: May 10, 2019

By: /Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
Customer No. 64735  
(949) 760-0404

30149493

Electronic Patent Application Fee Transmittal				
<b>Application Number:</b>	14981290			
<b>Filing Date:</b>	28-Dec-2015			
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS			
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze			
<b>Filer:</b>	Scott Cromar/Frances Tsai			
<b>Attorney Docket Number:</b>	MASCER.002C2			
Filed as Large Entity				
<b>Filing Fees for Utility under 35 USC 111(a)</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent-Appeals-and-Interference:</b>				
<b>Post-Allowance-and-Post-Issuance:</b>				
UTILITY APPL ISSUE FEE	1501	1	1000	1000

CX-1623

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1000

CX-1623

<b>Electronic Acknowledgement Receipt</b>	
<b>EFS ID:</b>	35977859
<b>Application Number:</b>	14981290
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9573
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	64735
<b>Filer:</b>	Scott Cromar/Chelsea Burdeno
<b>Filer Authorized By:</b>	Scott Cromar
<b>Attorney Docket Number:</b>	MASCER.002C2
<b>Receipt Date:</b>	10-MAY-2019
<b>Filing Date:</b>	28-DEC-2015
<b>Time Stamp:</b>	14:32:26
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$1000
RAM confirmation Number	051319INTEFSW14325100
Deposit Account	111410
Authorized User	Chelsea Veinot
<p>The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:</p> <p>37 CFR 1.16 (National application filing, search, and examination fees)</p> <p>37 CFR 1.17 (Patent application and reexamination processing fees)</p>	

Page 52 of 643

**Appx59412**

CX-1623

**File Listing:**

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	IssueFee_MASCER002C2.pdf	186109	no	1
			45bfbcd6a0ea1ad7ff7353ba1f262532feace75a8		

**Warnings:****Information:**

2	Post Allowance Communication - Incoming	Comments_MASCER002C2.pdf	32442	no	5
			26d48e8f4567f0b82ac8b1ebf60a3bcb89a30f68		

**Warnings:****Information:**

3	Fee Worksheet (SB06)	fee-info.pdf	30075	no	2
			22cbdbd927a2fdba16f959f5f3244e2eb5b7436d6		

**Warnings:****Information:**

<b>Total Files Size (in bytes):</b>	248626
-------------------------------------	--------

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 1 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	3,910,701	10/07/1975	Henderson et al.	
	2	4,114,604	09/19/1978	Shaw et al.	
	3	4,258,719	03/31/1981	Lewyn	
	4	4,267,844	05/19/1981	Yamanishi	
	5	4,444,471	04/24/1984	Ford et al.	
	6	4,655,225	04/07/1987	Dahne et al.	
	7	4,684,245	08/04/1987	Goldring	
	8	4,755,676	07/05/1988	Gaalema et al.	
	9	4,781,195	11/01/1988	Martin	
	10	4,805,623	02/21/1989	Jöbsis	
	11	4,880,304	11/14/1989	Jaeb et al.	
	12	4,960,128	10/02/1990	Gordon et al.	
	13	4,964,408	10/23/1990	Hink et al.	
	14	5,028,787	07/02/1991	Rosenthal, et al.	
	15	5,035,243	07/30/1991	Muz, Edwin	
	16	5,041,187	08/20/1991	Hink et al.	
	17	5,043,820	08/27/1991	Wyles et al.	
	18	5,069,213	12/03/1991	Polczynski	
	19	5,069,214	12/03/1991	Samaras et al.	
	20	5,077,476	12/31/1991	Rosenthal	
	21	5,086,229	02/04/1992	Rosenthal et al.	
	22	5,122,925	06/16/1992	Inpyn	
	23	5,131,391	07/21/1992	Sakai et al.	
	24	5,137,023	08/11/1992	Mendelson, et al.	
	25	5,159,929	11/03/1992	McMillen et al.	
	26	5,163,438	11/17/1992	Gordon et al.	
	27	5,222,295	06/29/1993	Dpriss Jr.	
	28	5,222,495	06/29/1993	Clarke et al.	
	29	5,222,496	06/29/1993	Clarke et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59414**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 2 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	5,249,576	10/05/1993	Goldberger et al.	
	31	5,278,627	01/11/1994	Aoyagi et al.	
	32	5,297,548	03/29/1994	Pologe, Jonas A.	
	33	5,319,355	06/07/1994	Russek	
	34	5,337,744	08/16/1994	Branigan	
	35	5,337,745	08/16/1994	Benaron	
	36	5,341,805	08/30/1994	Stavridi, et al.	
	37	5,362,966	11/08/1994	Rosenthal et al.	
	38	5,377,676	01/03/1995	Vari, et al.	
	39	5,427,093	06/27/1995	Ogawa et al.	
	40	5,431,170	07/11/1995	Mathews	
	41	5,437,275	08/01/1995	Amundsen et al.	
	42	5,441,054	08/15/1995	Tsuchiya	
	43	5,452,717	09/26/1995	Branigan et al.	
	44	5,456,252	10/10/1995	Vari, et al.	
	45	5,479,934	01/02/1996	Imran	
	46	5,482,034	01/09/1996	Lewis et al.	
	47	5,482,036	01/09/1996	Diab et al.	
	48	5,490,505	02/13/1996	Diab et al.	
	49	5,494,043	02/27/1996	O'Sullivan et al.	
	50	5,511,546	04/30/1996	Hon	
	51	5,533,511	07/09/1996	Kaspari et al.	
	52	5,534,851	07/09/1996	Russek	
	53	5,551,422	09/03/1996	Simonsen et al.	
	54	5,553,615	09/10/1996	Carim et al.	
	55	5,553,616	09/09/1996	Ham et al.	
	56	5,561,275	10/01/1996	Savage, et al.	
	57	5,562,002	10/08/1996	Lalin	
	58	5,590,649	01/07/1997	Caro et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59415**



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 3 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	5,602,924	02/11/1997	Durand et al.	
	60	5,625,458	04/29/1997	Alfano et al.	
	61	5,632,272	05/27/1997	Diab et al.	
	62	5,638,816	06/17/1997	Kiani-Azarbayjany et al.	
	63	5,638,818	06/17/1997	Diab et al.	
	64	5,645,440	07/08/1997	Tobler et al.	
	65	5,676,143	10/14/1997	Simonsen, et al.	
	66	5,685,299	11/11/1997	Diab et al.	
	67	5,743,262	04/28/1998	Lepper, Jr. et al.	
	68	5,750,927	05/12/1998	Baltazar, Osni	
	69	5,752,914	05/19/1998	Delonzor et al.	
	70	5,758,644	06/02/1998	Diab et al.	
	71	5,760,910	06/02/1998	Lepper, Jr. et al.	
	72	5,766,131	06/16/1998	Kondo et al.	
	73	5,769,785	06/23/1998	Diab et al.	
	74	5,782,757	07/21/1998	Diab et al.	
	75	5,785,659	07/28/1998	Caro et al.	
	76	5,791,347	08/11/1998	Flaherty et al.	
	77	5,792,052	08/11/1998	Isaacson et al.	
	78	5,810,734	09/22/1998	Caro et al.	
	79	5,823,950	10/20/1998	Diab et al.	
	80	5,826,885	10/27/1998	Helgeland	
	81	5,830,131	11/03/1998	Caro et al.	
	82	5,833,618	11/10/1998	Caro et al.	
	83	5,851,178	12/22/1998	Aronow	
	84	5,860,919	01/19/1999	Kiani-Azarbayjany et al.	
	85	5,890,929	04/06/1999	Mills et al.	
	86	5,902,235	05/11/1999	Lewis et al.	
	87	5,903,357	05/11/1999	Colak	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59416**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 4 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	5,904,654	05/18/1999	Wohltmann et al.	
	89	5,919,134	07/06/1999	Diab	
	90	5,934,925	08/10/1999	Tobler et al.	
	91	5,940,182	08/17/1999	Lepper, Jr. et al.	
	92	5,957,840	09/28/1999	Terasawa et al.	
	93	5,995,855	11/30/1999	Kiani et al.	
	94	5,997,343	12/07/1999	Mills et al.	
	95	6,002,952	12/14/1999	Diab et al.	
	96	6,011,986	01/04/2000	Diab et al.	
	97	6,027,452	02/22/2000	Flaherty et al.	
	98	6,036,642	03/14/2000	Diab et al.	
	99	6,045,509	04/04/2000	Caro et al.	
	100	6,049,727	04/11/2000	Crothall, Katherine D.	
	101	6,067,462	05/23/2000	Diab et al.	
	102	6,081,735	06/27/2000	Diab et al.	
	103	6,088,607	07/11/2000	Diab et al.	
	104	6,110,522	08/29/2000	Lepper, Jr. et al.	
	105	6,124,597	09/26/2000	Shehada	
	106	6,128,521	10/03/2000	Marro et al.	
	107	6,129,675	10/10/2000	Jay	
	108	6,144,866	11/07/2000	Miesel et al.	
	109	6,144,868	11/07/2000	Parker	
	110	6,151,516	11/21/2000	Kiani-Azarbayjany et al.	
	111	6,152,754	11/28/2000	Gerhardt et al.	
	112	6,157,850	12/05/2000	Diab et al.	
	113	6,165,005	12/26/2000	Mills et al.	
	114	6,172,743	01/09/2001	Kley, et al.	
	115	6,181,958	01/30/2001	Steuer et al.	
	116	6,184,521	02/06/2001	Coffin, IV et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59417**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 5 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	117	6,206,830	03/27/2001	Diab et al.	
	118	6,223,063	04/24/2001	Chaiken et al.	
	119	6,229,856	05/08/2001	Diab et al.	
	120	6,232,609	05/15/2001	Snyder, et al.	
	121	6,236,872	05/22/2001	Diab et al.	
	122	6,241,683	06/05/2001	Macklem, et al.	
	123	6,253,097	06/26/2001	Aronow et al.	
	124	6,256,523	07/03/2001	Diab et al.	
	125	6,263,222	07/17/2001	Diab et al.	
	126	6,278,522	08/21/2001	Lepper, Jr. et al.	
	127	6,278,889	08/21/2001	Robinson	
	128	6,280,213	08/28/2001	Tobler et al.	
	129	6,285,896	09/04/2001	Tobler et al.	
	130	6,301,493	10/09/2001	Marro et al.	
	131	6,317,627	11/13/2001	Ennen et al.	
	132	6,321,100	11/20/2001	Parker	
	133	6,325,761	12/04/2001	Jay	
	134	6,334,065	12/25/2001	Al-Ali et al.	
	135	6,343,223	01/29/2002	Chin et al.	
	136	6,343,224	01/29/2002	Parker	
	137	6,345,194	02/05/2002	Robert Nelson, et al.	
	138	6,349,228	02/19/2002	Kiani et al.	
	139	6,353,750	03/05/2002	Kimura et al.	
	140	6,360,113	03/09/2002	Dettling, Allen	
	141	6,360,114	03/09/2002	Diab et al.	
	142	6,360,115	03/19/2002	Roger Greenwald, et al.	
	143	6,368,283	04/09/2002	Xu, et al.	
	144	6,371,921	04/16/2002	Caro et al.	
	145	6,377,829	04/23/2002	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59418**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 6 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	146	6,388,240	05/14/2002	Schulz et al.	
	147	6,397,091	05/28/2002	Diab et al.	
	148	6,430,437	08/06/2002	Marro	
	149	6,430,525	08/06/2002	Weber et al.	
	150	6,463,311	10/08/2002	Diab	
	151	6,470,199	10/22/2002	Kopotic et al.	
	152	6,501,975	12/31/2002	Diab et al.	
	153	6,505,059	01/07/2003	Kollias, et al.	
	154	6,515,273	02/04/2003	Al-Ali	
	155	6,519,487	02/11/2003	Parker	
	156	6,522,521	02/18/2003	Abdul-Hafiz et al.	
	157	6,525,386	02/25/2003	Mills et al.	
	158	6,526,300	02/25/2003	Kiani et al.	
	159	6,541,756	04/01/2003	Schulz et al.	
	160	6,542,764	04/01/2003	Al-Ali et al.	
	161	6,580,086	06/17/2003	Schulz et al.	
	162	6,584,336	06/24/2003	Ali et al.	
	163	6,595,316	07/22/2003	Cybulski et al.	
	164	6,597,932	07/22/2003	Tian et al.	
	165	6,597,933	07/22/2003	Kiani et al.	
	166	6,606,509	08/12/2003	Schmitt, Joseph M.	
	167	6,606,511	08/12/2003	Ali et al.	
	168	6,632,181	10/14/2003	Flaherty et al.	
	169	6,636,759	10/21/2003	Robinson	
	170	6,639,668	10/28/2003	Trepagnier, Pierre	
	171	6,639,867	10/28/2003	Shim	Incomplete document listing
	172	6,639,867	10/28/2003	Shim	
	173	6,640,116	10/28/2003	Diab	
	174	6,643,530	11/04/2003	Diab et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 7 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	175	6,650,917	11/18/2003	Diab et al.	
	176	6,654,624	11/25/2003	Diab et al.	
	177	6,658,276	12/02/2003	Diab et al.	
	178	6,661,161	12/09/2003	Lanzo et al.	
	179	6,668,185	12/23/2003	Toida	
	180	6,671,531	12/30/2003	Al-Ali et al.	
	181	6,678,543	01/13/2004	Diab et al.	
	182	6,681,133	01/20/2004	Chaiken et al.	
	183	6,684,090	01/27/2004	Ali et al.	
	184	6,684,091	01/27/2004	Parker	
	185	6,697,656	02/24/2004	Al-Ali	
	186	6,697,657	02/24/2004	Shehada, et al.	
	187	6,697,658	02/24/2004	Al-Ali	
	188	6,699,194	03/02/2004	Diab et al.	
	189	6,714,804	03/30/2004	Al-Ali et al.	
	190	6,721,582	04/13/2004	Trepagnier, et al.	
	191	6,721,585	04/13/2004	Parker	
	192	6,725,075	04/20/2004	Al-Ali	
	193	6,728,560	04/27/2004	Kollias, et al.	
	194	6,735,459	05/11/2004	Parker	
	195	6,745,060	06/01/2004	Diab et al.	
	196	6,748,254	06/08/2004	O'Neil et al.	
	197	6,760,607	07/06/2004	Al-Ali	
	198	6,770,028	08/03/2004	Ali et al.	
	199	6,771,994	08/03/2004	Kiani et al.	
	200	6,792,300	09/14/2004	Diab et al.	
	201	6,813,511	11/02/2004	Diab et al.	
	202	6,816,010	11/09/2004	Seetharaman et al.	
	203	6,816,241	11/09/2004	Grubisic, et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59420**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 8 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	204	6,816,741	11/09/2004	Diab	
	205	6,822,564	11/23/2004	Al-Ali	
	206	6,826,419	11/30/2004	Diab et al.	
	207	6,830,711	12/14/2004	Mills et al.	
	208	6,850,787	02/01/2005	Weber et al.	
	209	6,850,788	02/01/2005	Al-Ali	
	210	6,852,083	02/08/2005	Caro et al.	
	211	6,861,639	03/01/2005	Al-Ali	
	212	6,898,452	05/24/2005	Al-Ali et al.	
	213	6,912,413	06/28/2005	Rantala et al.	
	214	6,920,345	07/19/2005	Al-Ali et al.	
	215	6,931,268	08/16/2005	Kiani-Azarbayjany et al.	
	216	6,934,570	08/23/2005	Kiani et al.	
	217	6,939,305	09/06/2005	Flaherty et al.	
	218	6,943,348	09/13/2005	Coffin IV	
	219	6,950,687	09/27/2005	Al-Ali	
	220	6,961,598	11/01/2005	Diab	
	221	6,970,792	11/29/2005	Diab	
	222	6,979,812	12/27/2005	Al-Ali	
	223	6,985,764	01/10/2006	Mason et al.	
	224	6,993,371	01/31/2006	Kiani et al.	
	225	6,995,400	02/07/2006	Mizuyoshi	
	226	6,996,427	02/07/2006	Ali et al.	
	227	6,999,904	02/14/2006	Weber et al.	
	228	7,003,338	02/21/2006	Weber et al.	
	229	7,003,339	02/21/2006	Diab et al.	
	230	7,015,451	03/21/2006	Dalke et al.	
	231	7,024,233	04/04/2006	Ali et al.	
	232	7,027,849	04/11/2006	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59421**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 9 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	233	7,030,749	04/18/2006	Al-Ali	
	234	7,039,449	05/02/2006	Al-Ali	
	235	7,041,060	05/09/2006	Flaherty et al	
	236	7,044,918	05/16/2006	Diab	
	237	7,047,054	05/16/2006	Benni	
	238	7,067,893	06/27/2006	Mills et al.	
	239	7,092,757	08/15/2006	Larson et al.	
	240	7,096,052	08/22/2006	Mason et al.	
	241	7,096,054	08/22/2006	Abdul-Hafiz et al.	
	242	7,132,641	11/07/2006	Schulz et al.	
	243	7,142,901	11/28/2006	Kiani et al.	
	244	7,149,561	12/12/2006	Diab	
	245	7,186,966	03/06/2007	Al-Ali	
	246	7,190,261	03/13/2007	Al-Ali	
	247	7,215,984	05/08/2007	Diab	
	248	7,215,986	05/08/2007	Diab	
	249	7,221,971	05/22/2007	Diab	
	250	7,225,006	05/29/2007	Al-Ali et al.	
	251	7,225,007	05/29/2007	Al-Ali	
	252	7,230,227	06/12/2007	Wilcken et al.	
	253	7,239,905	07/03/2007	Kiani-Azarbayjany et al.	
	254	7,245,953	07/17/2007	Parker	
	255	7,254,429	08/07/2007	Schurman et al.	
	256	7,254,431	08/07/2007	Al-Ali	
	257	7,254,433	08/07/2007	Diab et al.	
	258	7,254,434	08/07/2007	Schulz et al.	
	259	7,272,425	09/18/2007	Al-Ali	
	260	7,274,955	09/25/2007	Kiani et al.	
	261	7,280,858	10/09/2007	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59422**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 10 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	262	7,289,835	10/30/2007	Mansfield et al.	
	263	7,292,883	11/06/2007	De Felice et al.	
	264	7,295,866	11/13/2007	Al-Ali	
	265	7,328,053	02/05/2008	Diab et al.	
	266	7,332,784	02/19/2008	Mills, et al.	
	267	7,340,287	03/04/2008	Mason et al.	
	268	7,341,559	03/11/2008	Schulz et al.	
	269	7,343,186	03/11/2008	Lamego et al.	
	270	7,355,512	04/08/2008	Al-Ali	
	271	7,356,365	04/08/2008	Schurman	
	272	7,365,923	04/29/2008	Hargis et al.	
	273	7,371,981	05/13/2008	Abdul-Hafiz	
	274	7,373,193	05/13/2008	Al-Ali et al.	
	275	7,373,194	05/13/2008	Weber et al.	
	276	7,376,453	05/20/2008	Diab et al.	
	277	7,377,794	05/27/2008	Al Ali et al.	
	278	7,377,899	05/27/2008	Weber et al.	
	279	7,383,070	06/03/2008	Diab et al.	
	280	7,395,189	07/01/2008	Qing et al.	
	281	7,415,297	08/19/2008	Al-Ali et al.	
	282	7,428,432	09/23/2008	Ali et al.	
	283	7,438,683	10/21/2008	Al-Ali et al.	
	284	7,440,787	10/21/2008	Diab	
	285	7,454,240	11/18/2008	Diab et al.	
	286	7,467,002	12/16/2008	Weber et al.	
	287	7,469,157	12/23/2008	Diab et al.	
	288	7,471,969	12/30/2008	Diab et al.	
	289	7,471,971	12/30/2008	Diab et al.	
	290	7,483,729	01/27/2009	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59423**



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 11 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	291	7,483,730	01/27/2009	Diab et al.	
	292	7,489,958	02/10/2009	Diab et al.	
	293	7,496,391	02/24/2009	Diab et al.	
	294	7,496,393	02/24/2009	Diab et al.	
	295	7,499,741	03/03/2009	Diab et al.	
	296	7,499,835	03/03/2009	Weber et al.	
	297	7,500,950	03/10/2009	Al-Ali et al.	
	298	7,509,153	03/24/2009	Blank et al.	
	299	7,509,154	03/24/2009	Diab et al.	
	300	7,509,494	03/24/2009	Al-Ali	
	301	7,510,849	03/31/2009	Schurman et al.	
	302	7,526,328	04/28/2009	Diab et al.	
	303	7,530,942	05/12/2009	Diab	
	304	7,530,949	05/12/2009	Al Ali et al.	
	305	7,530,955	05/12/2009	Diab et al.	
	306	7,563,110	07/21/2009	Al-Ali et al.	
	307	7,596,398	09/29/2009	Al-Ali et al.	
	308	7,606,606	10/20/2009	Laakkonen	
	309	7,618,375	11/17/2009	Flaherty	
	310	7,647,083	01/12/2010	Al-Ali et al.	
	311	7,657,294	02/02/2010	Eghbal et al.	
	312	7,657,295	02/02/2010	Coakley et al.	
	313	7,657,296	02/02/2010	Raridan et al.	
	314	7,729,733	06/01/2010	Al-Ali et al.	
	315	7,734,320	06/08/2010	Al-Ali	
	316	7,761,127	07/20/2010	Al-Ali et al.	
	317	7,761,128	07/20/2010	Al-Ali et al.	
	318	7,764,982	07/27/2010	Dalke et al.	
	319	7,791,155	09/07/2010	Diab	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59424**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 12 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	320	7,801,581	09/21/2010	Diab	
	321	7,809,418	10/05/2010	Xu	
	322	7,822,452	10/26/2010	Schurman et al.	
	323	7,844,313	11/30/2010	Kiani et al.	
	324	7,844,314	11/30/2010	Al-Ali	
	325	7,844,315	11/30/2010	Al-Ali	
	326	7,865,222	01/04/2011	Weber et al.	
	327	7,873,497	01/18/2011	Weber et al.	
	328	7,880,606	02/01/2011	Al-Ali	
	329	7,880,626	02/01/2011	Al-Ali et al.	
	330	7,891,355	02/22/2011	Al-Ali et al.	
	331	7,894,868	02/22/2011	Al-Ali et al.	
	332	7,899,506	03/01/2011	Xu et al.	
	333	7,899,507	03/01/2011	Al-Ali et al.	
	334	7,899,518	03/01/2011	Trepagnier et al.	
	335	7,904,132	03/08/2011	Weber et al.	
	336	7,909,772	03/22/2011	Popov et al.	
	337	7,910,875	03/22/2011	Al-Ali	
	338	7,919,713	04/05/2011	Al-Ali et al.	
	339	7,937,128	05/03/2011	Al-Ali	
	340	7,937,129	05/03/2011	Mason et al.	
	341	7,937,130	05/03/2011	Diab et al.	
	342	7,941,199	05/10/2011	Kiani	
	343	7,951,086	05/31/2011	Flaherty et al.	
	344	7,957,780	06/07/2011	Lamego et al.	
	345	7,962,188	06/14/2011	Kiani et al.	
	346	7,962,190	06/14/2011	Diab et al.	
	347	7,976,472	07/12/2011	Kiani	
	348	7,988,637	08/02/2011	Diab	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59425**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 13 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	349	7,990,382	08/02/2011	Kiani	
	350	7,991,446	08/02/2011	Al-Ali et al.	
	351	8,000,761	08/16/2011	Al-Ali	
	352	8,008,088	08/08/2011	Bellott et al.	
	353	8,019,400	09/13/2011	Diab et al.	
	354	8,028,701	10/04/2011	Al-Ali et al.	
	355	8,029,765	10/04/2011	Bellott et al.	
	356	8,036,728	10/11/2011	Diab et al.	
	357	8,044,998	10/25/2011	Heenan	
	358	8,046,040	10/25/2011	Ali et al.	
	359	8,046,041	10/25/2011	Diab et al.	
	360	8,046,042	10/25/2011	Diab et al.	
	361	8,048,040	11/01/2011	Kiani	
	362	8,050,728	11/01/2011	Al-Ali et al.	
	363	8,118,620	02/21/2012	Al-Ali et al.	
	364	8,126,528	02/28/2012	Diab et al.	
	365	8,126,531	02/28/2012	Crowley	
	366	8,128,572	03/06/2012	Diab et al.	
	367	8,130,105	03/06/2012	Al-Ali et al.	
	368	8,145,287	03/27/2012	Diab et al.	
	369	8,150,487	04/03/2012	Diab et al.	
	370	8,175,672	05/08/2012	Parker	
	371	8,180,420	05/15/2012	Diab et al.	
	372	8,182,443	05/22/2012	Kiani	
	373	8,185,180	05/22/2012	Diab et al.	
	374	8,190,223	05/29/2012	Al-Ali et al.	
	375	8,190,227	05/29/2012	Diab et al.	
	376	8,203,438	06/19/2012	Kiani et al.	
	377	8,203,704 (CERCA.004A)	06/19/2012	Merritt et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59426**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 14 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	378	8,219,170	07/10/2012	Hausmann et al.	
	379	8,224,411	07/17/2012	Al-Ali et al.	
	380	8,228,181	07/24/2012	Al-Ali	
	381	8,229,533	07/24/2012	Diab et al.	
	382	8,233,955	07/31/2012	Al-Ali et al.	
	383	8,244,325	08/14/2012	Al-Ali et al.	
	384	8,255,026	08/28/2012	Al-Ali	
	385	8,255,027	08/28/2012	Al-Ali et al.	
	386	8,255,028	08/28/2012	Al-Ali et al.	
	387	8,260,577	09/04/2012	Weber et al.	
	388	8,265,723	09/11/2012	McHale et al.	
	389	8,274,360	09/25/2012	Sampath et al.	
	390	8,301,217	10/30/2012	Al-Ali et al.	
	391	8,310,336	11/13/2012	Muhsin et al.	
	392	8,315,683	11/20/2012	Al-Ali et al.	
	393	8,332,006	12/11/2012	Naganuma et al.	
	394	8,337,403	12/25/2012	Al-Ali et al.	
	395	8,346,330	01/01/2013	Lamego	
	396	8,353,842	01/15/2013	Al-Ali et al.	
	397	8,355,766	01/15/2013	MacNeish, III et al.	
	398	8,359,080	01/22/2013	Diab et al.	
	399	8,364,223	01/29/2013	Al-Ali et al.	
	400	8,364,226	01/29/2013	Diab et al.	
	401	8,374,665	02/12/2013	Lamego	
	402	8,380,272	02/19/2013	Barrett et al.	
	403	8,385,995	02/26/2013	Al-ali et al.	
	404	8,385,996	02/26/2013	Smith et al.	
	405	8,388,353	03/05/2013	Kiani et al.	
	406	8,399,822	03/19/2013	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59427**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 15 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	407	8,401,602	03/19/2013	Kiani	
	408	8,405,608	03/26/2013	Al-Ali et al.	
	409	8,414,499	04/09/2013	Al-Ali et al.	
	410	8,418,524	04/16/2013	Al-Ali	
	411	8,421,022	04/16/2013	Rozenfeld	
	412	8,423,106	04/16/2013	Lamego et al.	
	413	8,428,674	04/23/2013	Duffy et al.	
	414	8,428,967	04/23/2013	Olsen et al.	
	415	8,430,817	04/30/2013	Al-Ali et al.	
	416	8,437,825 (CERCA.007A)	05/07/2013	Dalvi et al.	
	417	8,455,290	06/04/2013	Siskavich	
	418	8,457,703	06/04/2013	Al-Ali	
	419	8,457,707	06/04/2013	Kiani	
	420	8,463,349	06/11/2013	Diab et al.	
	421	8,466,286	06/18/2013	Bellot et al.	
	422	8,471,713	06/25/2013	Poeze et al.	
	423	8,473,020	06/25/2013	Kiani et al.	
	424	8,483,787	07/09/2013	Al-Ali et al.	
	425	8,489,364	07/16/2013	Weber et al.	
	426	8,498,684	07/30/2013	Weber et al.	
	427	8,509,867	08/13/2013	Workman et al.	
	428	8,515,509 (CERCA.005A)	08/20/2013	Bruinsma et al.	
	429	8,523,781	09/03/2013	Al-Ali	
	430	8,529,301	09/10/2013	Al-Ali et al.	
	431	8,532,727	09/10/2013	Ali et al.	
	432	8,532,728	09/10/2013	Diab et al.	
	433	8,547,209	10/01/2013	Kiani et al.	
	434	8,548,548	10/01/2013	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59428**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 16 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	435	8,548,550	10/01/2013	Al-Ali et al.	
	436	8,560,032	10/15/2013	Al-Ali et al.	
	437	8,560,034	10/15/2013	Diab et al.	
	438	8,570,503 (CERCA.004C1)	10/29/2013	Hung Vo	
	439	8,577,431 (CERCA.006A)	11/05/2013	Lamego et al.	
	440	8,584,345	10//2013	Al-Ali et al.	
	441	8,588,880	11//2013	Abdul-Hafiz et al.	
	442	8,600,467	12//2013	Al-Ali et al.	
	443	8,602,971	12/10/2013	Farr	
	444	8,606,342	12//2013	Diab	
	445	8,626,255	01//2014	Al-Ali et al.	
	446	8,630,691 (CERCA.003A)	01/14/2014	Lamego et al.	
	447	8,634,889	01//2014	Al-Ali et al.	
	448	8,641,631	02//2014	Sierra et al.	
	449	8,652,060	02//2014	Al-Ali	
	450	8,663,107	03//2014	Kiani	
	451	8,666,468	03//2014	Al-Ali	
	452	8,667,967	03//2014	Al-Ali et al.	
	453	8,670,811	03//2014	O'Reilly	
	454	8,670,814	03//2014	Diab et al.	
	455	8,676,286	03//2014	Weber et al.	
	456	8,682,407	03//2014	Al-Ali	
	457	8,688,183 (CERCA.008A)	04/01/2014	Bruinsma et al.	
	458	8,690,799	04//2014	Telfort et al.	
	459	8,700,112	04//2014	Kiani	
	460	8,702,627	04//2014	Telfort et al.	
	461	8,706,179	04//2014	Parker	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 17 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	462	8,712,494	04//2014	MacNeish, III et al.	
	463	8,715,206	05//2014	Telfort et al.	
	464	8,718,735	05//2014	Lamego et al.	
	465	8,718,737	05//2014	Diab et al.	
	466	8,720,249	05//2014	Al-Ali	
	467	8,721,541	05//2014	Al-Ali et al.	
	468	8,721,542	05//2014	Al-Ali et al.	
	469	8,723,677	05//2014	Kiani	
	470	8,740,792	06//2014	Kiani et al.	
	471	8,754,776	06//2014	Poeze et al.	
	472	8,755,535	06//2014	Telfort et al.	
	473	8,755,856	06//2014	Diab et al.	
	474	8,755,872	06//2014	Marinow	
	475	8,761,850	06//2014	Lamego	
	476	8,909,310 (CERCA.003D1)	12/09/2014	Lamego et al.	
	477	9,186,102 (MASCER.008C1)	11/17/2015	Bruinsma et al.	
	478	2002/0099279	07/25/2002	Pfeiffer et al.	
	479	2006/0005944	01/12/2006	Wang et al.	
	480	2006/0025659	02/02/2006	Kiguchi et al.	
	481	2007/0293792	12/20/2007	Sliwa et al.	
	482	2008/0130232	06/05/2008	Yamamoto	
	483	2008/0139908	06/12/2008	Kurth	
	484	2009/0030327	01/29/2009	Chance, Britton	
	485	2009/0043180	02/12/2009	Tschautscher et al.	
	486	2009/0129102	05/21/2009	Xiao et al.	
	487	2009/0259114	10/15/2009	Johnson et al.	
	488	2010/0004518 (011A)	01/07/2010	Vo et al.	
	489	2010/0030040 (CERCA.002A)	02/04/2010	Poeze et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59430**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 18 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	490	2011/0004082 (CERCA.002C1)	01/06/2011	Poeze et al.	
	491	2011/0105865	05/05/2011	Yu et al.	
	492	2013/0317370 (CERCA.007C1)	11/28/2013	Dalvi et al.	
	493	2014/0066783 (CERCA.006C1)	03/06/2014	Kiani et al.	
	494	2014/0296664 (CERCA.008C1)	03/27/2014	Bruinsma et al.	
	495	2014/0155712 (CERCA.003D1)	06/05/2014	Lamego et al.	
	496	D326,715	06/02/1992	Schmidt, Michael	
	497	D353,195	12/06/1994	Savage et al.	
	498	D353,196	12/06/1994	Savage et al.	
	499	D356,870	03/28/1995	Ivers et al.	
	500	D359,546	06/20/1995	Savage, et al.	
	501	D361,840	08/29/1995	Savage et al.	
	502	D362,063	09/05/1995	Savage et al.	
	503	D363,120	10/10/1995	Savage et al.	
	504	D378,414	03/11/1997	Allen et al.	
	505	D390,666	02/01/1998	Lagerlof, Ingemar	
	506	D393,830	04/28/1998	Tobler et al.	
	507	D403,070	12/22/1998	Maeda et al.	
	508	D414,870	10/05/1999	Saltzstein et al.	
	509	D452,012	12/11/2001	Phillips, Barney L.	
	510	D455,834	04/16/2002	Donars et al.	
	511	D463,561	09/24/2002	Fukatsu et al.	
	512	D481,459	10/28/2003	Nahm, Werner	
	513	D502,655	03/08/2005	Huang, Chun-Mu	
	514	D508,862	08/30/2005	Behar et al.	
	515	D510,625	10/11/2005	Widener et al.	
	516	D514,461	02/07/2006	Harju, Jonne	
	517	D535,031	01/09/2007	Barrett et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59431**



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 19 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	518	D537,164	02/20/2007	Shigemori et al.	
	519	D547,454	07/24/2007	Hsieh, Chin-Chih	
	520	D549,830	08/28/2007	Behar et al.	
	521	D550,364	09/04/2007	Glover et al.	
	522	D551,350	09/18/2007	Lorimer et al.	
	523	D553,248	10/16/2007	Nguyen	
	524	D554,263	10/30/2007	Al-Ali	
	525	D562,985	02/26/2008	Brefka et al.	
	526	D566,282	04/08/2008	Al-Ali et al.	
	527	D567,125	04/22/2008	Okabe et al.	
	528	D569,001	05/13/2008	Omaki	
	529	D569,521	05/20/2008	Omaki	
	530	D587,657	03/03/2009	Al-Ali et al.	
	531	D603,966	11/10/2009	Jones et al.	
	532	D606,659 (010DA)	12/22/2009	Kiani et al.	
	533	D609,193	02/02/2010	Al-Ali et al.	
	534	D614,305	04/20/2010	Al-Ali et al.	
	535	D621,516 (009DA)	08/10/2010	Kiani et al.	
	536	D692,145	10/22/2013	Al-Ali et al.	
	537	RE38,476	03/01/2004	Diab et al.	
	538	RE38,492	04/06/2004	Diab et al.	
	539	RE39,672	06/05/2007	Shehada et al.	
	540	RE41,317	05/04/2010	Parker	
	541	RE41,912	11/02/2010	Parker	
	542	RE42,753	09/27/2011	Kiani-Azarbayjany et al.	
	543	RE43,169	02/07/2012	Parker	
	544	RE43,860	12/11/2012	Parker	
	545	RE44,823	04/2014	Parker	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59432**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 20 OF 22	Attorney Docket No.	MASCER.002C2

## U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	546	RE44,875	04/2014	Kiani et al.	

## FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document Country Code-Number-Kind Code Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T <sup>1</sup>
	547	EP 419223	03/27/1991	Minnesota Mining and Manufacturing Company		
	548	JP 5756752 (MASCER.007JP)	06/05/2015	MASIMO LABORATORIES, INC.		
	549	JP 2002-500908 A	01/15/2002	Lightouch Medical Inc.		Abs
	550	JP 2007-389463 A	11/08/2007	Konica Minolta Sensing Inc.		Abs
	551	JP 2003-265444 A	09/24/2003	Shimadzu Corp.		Abs
	552	JP 06-327658 A /app JP 08-185864 /pub	07/16/1996	Matsushita Electric Ind Co Ltd		Abs
	553	JP 11-244266 /app JP 2001-66990 /pub	03/16/2001	Sumitomo Bakelite Co Ltd		Abs
	554	JP 04-158843 / app JP 05-325705 A / pub	12/10/1993	Fuji Porimatetsuku KK		Abs
	555	JP 2001-087250 A	04/03/2001	Cas Medical Systems Inc.		Abs
	556	JP 2006-177837 A	07/06/2006	Hitachi Ltd.		Abs
	557	JP 2003-024276 A	01/28/2003	Pentax Corp.		Abs
	558	JP 2008-099222 A	04/24/2008	Konica Minolta Holdings Inc.		Abs
	559	JP 2006-198321 A	08/03/2006	Hitachi Ltd.		Abs
	560	JP 2003-508104 A	03/04/2003	Quantum Vision Inc.		Abs
	561	WO 1993/12712	07/08/1993	Vivascan Corp		
	562	WO 1999/000053	01/07/1999	TOA Medical Electronics		
	563	WO 2000/25112	05/04/2000	Rolfe		
	564	WO 2014/149781 (CERCA.082WO)	09/25/2014	Cercacor Laboratories, Inc.		
	565	WO 2014/158820 (CERCA.067WO)	10/02/2014	Cercacor Laboratories, Inc.		
	566	WO 1999/01704	07/29/1999	General Electric Company		

## NON PATENT LITERATURE DOCUMENTS

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

Appx59433

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown	
	Filing Date	Herewith	
	First Named Inventor	Jeroen Poeze	
	Art Unit	Unknown	
(Multiple sheets used when necessary)		Examiner	Unknown
SHEET 21 OF 22		Attorney Docket No.	MASCER.002C2

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	567	PCT International Search Report, App. No. PCT/US2010/047899, Date of Actual Completion of Search: 01/26/2011, 4 pages.	
	568	International Search Report and Written Opinion for PCT/US2009/049638, mailed January 7, 2010.	
	569	International Search Report issued in Application No. PCT/US2009/052756, mailed February 10, 2009 in 14 pages.	
	570	International Preliminary Report on Patentability and Written Opinion of the International Searching Authority issued in Application No. PCT US2009/049638, mailed January 5, 2011 in 9 pages.	
	571	International Preliminary Report on Patentability and Written Opinion of the International Searching Authority issued in Application No. PCT/US2009/052756, mailed February 8, 2011 in 8 pages.	
	572	Burritt, Mary F.; Current Analytical Approaches to Measuring Blood Analytes; Vol. 36; No. 8(B); 1990	
	573	Hall, et al., Jeffrey W.; Near-Infrared Spectrophotometry: A New Dimension in Clinical Chemistry; Vol. 38; No. 9; 1992	
	574	Kuenstner, et al., J. Todd; Measurement of Hemoglobin in Unlysed Blood by Near-Infrared Spectroscopy; Vol. 48; Number 4, 1994	
	575	Manzke, et al., B., Multi Wavelength Pulse Oximetry in the Measurement of Hemoglobin Fractions; SPIE, Vol. 2676, April 24, 1996	
	576	Naumenko, E. K.; Choice of Wavelengths for Stable Determination of Concentrations of Hemoglobin Derivatives from Absorption Spectra of Erythrocytes; Vol. 63; No. 1; pp. 60-66 January – February 1996; Original article submitted November 3, 1994	
	577	Schmitt, Joseph M.; Simple Photon Diffusion Analysis of the Effects of Multiple Scattering on Pulse Oximetry; March 14, 1991; revised August 30, 1991	
	578	Schmitt, et al., Joseph M.; Measurement of Blood Hematocrit by Dual-Wavelength near-IR Photoplethysmography; Vol. 1641; 1992	
	579	Schnapp, et al., L.M.; Pulse Oximetry. Uses and Abuses.; Chest 1990; 98; 1244-1250 DOI 10.1378/Chest.98.5.1244	
	580	<a href="http://www.masimo.com/rainbow/pronto.htm">http://www.masimo.com/rainbow/pronto.htm</a> Noninvasive & Immediate Hemoglobin Testing, printed on August 20, 2009	
	581	<a href="http://www.masimo.com/pulseOximeter/Rad5.htm">http://www.masimo.com/pulseOximeter/Rad5.htm</a> ; Signal Extraction Pulse Oximeter, printed on August 20, 2009	
	582	<a href="http://blogderoliveira.blogspot.com/2008_02_01_archive.html">http://blogderoliveira.blogspot.com/2008_02_01_archive.html</a> ; Ricardo Oliveira, printed on August 20, 2009	
	583	<a href="http://www.masimo.com/rad-57/">http://www.masimo.com/rad-57/</a> ; Noninvasive Measurement of Methemoglobin, Carboxyhemoglobin and Oxyhemoglobin in the blood. Printed on August 20, 2009	
	584	<a href="http://amivital.ugr.es/blog/?tag=spo2">http://amivital.ugr.es/blog/?tag=spo2</a> ; Monitorizacion de la hemoglobina...y mucho mas, printed on August 20, 2009	
	585	<a href="http://www.masimo.com/spco/">http://www.masimo.com/spco/</a> ; Carboxyhemoglobin Noninvasive > Continuous > Immediate, printed on August 20, 2009	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59434**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
SHEET 22 OF 22		Attorney Docket No. MAS CER.002C2

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	586	http://www.masimo.com/PARTNERS/WELCHALLYN.htm; Welch Allyn Expands Patient Monitor Capabilities with Masimo Pulse Oximetry Technology, printed on August 20, 2009	
	587	http://www.masimo.com/pulseOximeter/PPO.htm; Masimo Personal Pulse Oximeter, printed on August 20, 2009	
	588	http://www.masimo.com/generalFloor/system.htm; Masimo Patient SafetyNet System at a Glance, printed on August 20, 2009	
	589	http://www.masimo.com/partners/GRASEBY.htm; Graseby Medical Limited, printed on August 20, 2009	
	590	Japanese Office Action, re JP Application No. 2011-516895, mailed September 2, 2014, with translation. (CERCA.007JP).	
	591	Japanese Notice of Allowance, re JP Application No. 2011-516895, issued on May 12, 2015, no translation. (CERCA/MAS CER.007JP).	
	592	European Office Action issued in application no. 10763901.5 on 01/11/2013. (CERCA.008EP).	
	593	European Office Action issued in application no. 10763901.5 on 08/27/2014. (CERCA.008EP).	
	594	European Office Action issued in application no. 10763901.5 on 08/06/2015. (CERCA.008EP).	
	595	KANUKURTHY et al., "Data Acquisition Unit for an Implantable Multi-Channel Optical Glucose Sensor", Electro/Information Technology Conference, Chicago, IL, USA, May 17-20, 2007, pp. 1-6	
	596	SMITH, "The Pursuit of Noninvasive Glucose: 'Hunting the Deceitful Turkey'", 2006	
	597	SMALL et al., "Data Handling Issues for Near-Infrared Glucose Measurements", http://www.ieee.org/organizations/pubs/newsletters/leos/apr98/datahandling.htm, accessed 11/27/2007	

22330084

Examiner Signature	/CHU CHUAN LIU/	Date Considered	07/02/2018
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.			

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

Appx59435

Docket Number: MASCER.002C2

**APPLICATION DATA SHEET****Application Information**

Application Number: 14/981290  
 Filing Date: December 28, 2015  
 Application Type: Nonprovisional  
 Subject Matter: Utility  
 Title: MULTI-STREAM DATA COLLECTION SYSTEM FOR  
 NONINVASIVE MEASUREMENT OF BLOOD  
 CONSTITUENTS  
 Attorney Docket Number: MASCER.002C2

**Domestic Priority Information**

Prior Application Status		Pending <u>Patented</u>			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
This Application	Continuation of	12/829352	2010-07-01	<u>9277880</u>	<u>2016-03-08</u>

Prior Application Status		Abandoned			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:		
12/829352	Continuation of	12/534827	2009-08-03		

Prior Application Status		Expired			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:		
12/534827	Claims benefit of provisional	61/086060	2008-08-04		

Prior Application Status		Expired			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:		
12/534827	Claims benefit of provisional	61/086108	2008-08-04		

Prior Application Status		Expired			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:		
12/534827	Claims benefit of provisional	61/086063	2008-08-04		

1

14/981290

Filed: December 28, 2015

Docket Number: MASCER.002C2

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/534827	Claims benefit of provisional	61/086057	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/534827	Claims benefit of provisional	61/091732	2008-08-25

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/829352	Continuation of	12/497528	2009-07-02	8577431	2013-11-03

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/086060	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/086108	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/086063	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/086057	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/078228	2008-07-03

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/078207	2008-07-03

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497528	Claims benefit of provisional	61/091732	2008-08-25

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/497528	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/497528	Continuation in part of	29/323408	2008-08-25	D606659	2009-12-22

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/829352	Continuation of	12/497523	2009-07-02	8437825	2013-05-07

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/086060	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/086108	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/086063	2008-08-04

Docket Number: MASCER.002C2

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/086057	2008-08-04

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/078228	2008-07-03

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/078207	2008-07-03

Prior Application Status		Expired	
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:
12/497523	Claims benefit of provisional	61/091732	2008-08-25

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/497523	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10

Prior Application Status		Patented			
Application No.:	Continuity Type:	Prior Application No.:	Filing Date:	Patent No.:	Issue Date:
12/497523	Continuation in part of	<del>29/323409</del>	2008-08-25	<del>D621516</del>	<del>2010-08-10</del>
		<u>29/323408</u>		<u>D606659</u>	<u>2009-12-22</u>



**Correspondence Information**

Correspondence Customer Number: 64735

E-Mail Address: efiling@knobbe.com

Dated: March 13, 2019

By: /Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
Customer No. 64735  
(949) 760-0404

30118155

CX-1623

Electronic Acknowledgement Receipt	
<b>EFS ID:</b>	35410305
<b>Application Number:</b>	14981290
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9573
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	64735
<b>Filer:</b>	Scott Cromar/Melissa Ramirez
<b>Filer Authorized By:</b>	Scott Cromar
<b>Attorney Docket Number:</b>	MASCER.002C2
<b>Receipt Date:</b>	13-MAR-2019
<b>Filing Date:</b>	28-DEC-2015
<b>Time Stamp:</b>	15:12:41
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	no
------------------------	----

**File Listing:**

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Post Allowance Communication - Incoming	Response_MASCER002C2.pdf	133959 9460dd884976c3888364edc10b0ac433f0c2642d	no	3

**Warnings:**

Page 81 of 643

**Appx59441**

CX-1623

<b>Information:</b>					
2	Application Data Sheet	ADS_MASCER002C2.pdf	49871	no	5
			640e160d4e692a4ac63e58775844fa570e61abe		
<b>Warnings:</b>					
<b>Information:</b>					
This is not an USPTO supplied ADS fillable form					
<b>Total Files Size (in bytes):</b>			183830		
<p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>  If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>  If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>  If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p>					

Docket No.: MASCER.002C2

March 13, 2019

Page 1 of 1

Please Direct All Correspondence to Customer Number 64735

---

**RESPONSE TO NOTICE TO FILE CORRECTED APPLICATION PAPERS**

Inventor	: Jeroen Poeze
App. No.	: 14/981290
Filed	: December 28, 2015
For	: MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Art Unit	: 3791
Conf No.	: 9573

---

**Mail Stop Issue Fee  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450**

Dear Commissioner:

In response to the Notice to File Corrected Application Papers dated March 12, 2019, in connection with the above-identified patent application, Applicant respectfully submits the following:

- (X) A copy of the Notice to File Corrected Application Papers
- (X) Corrected Application Data Sheet

The Application Data Sheet includes corrections to an application number noted in the above Notice. Applicant notes that both the filing receipt mailed January 19, 2016, and the updated filing receipt mailed March 9, 2016, reflect/recognize the benefit claim.

The Commissioner is hereby authorized to charge any additional fees which may be required, now or in the future, or credit any overpayment, to Account No. 11-1410.

/Scott Cromar/  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
Customer No. 64735  
(949) 760-0404

30118183



UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents  
United States Patent and Trademark Office  
P.O. Box 1450  
Alexandria, VA 22313-1450  
www.uspto.gov

Application No. : 14981290  
Applicant : Poeze  
Filing Date : 12/28/2015  
Date Mailed : 03/12/2019

## NOTICE TO FILE CORRECTED APPLICATION PAPERS

### *Notice of Allowance Mailed*

This application has been accorded an Allowance Date and is being prepared for issuance. The application, however, is incomplete for the reasons below.

**Applicant is given two (2) months from the mail date of this Notice within which to respond. This time period for reply is extendable under 37 CFR 1.136(a) for only TWO additional MONTHS.**

The application is not in compliance with 37 CFR 1.78, as indicated in the attachment. The consequences of failure to respond within the above-identified time period are set forth in the attachment.

Even if the Office has recognized a benefit claim and has entered it into the Office's database and included it on applicant's filing receipt, the benefit claim is not a proper benefit claim unless the reference in compliance with 37 CFR 1.78 is included, depending upon the application's filing date and as indicated in the attachment, in an application data sheet or in the first sentence(s) of the specification and all other requirements are met.

See attachment.

*A copy of this notice **MUST** be returned with the reply. Please address response to  
"Mail Stop Issue Fee, Commissioner for Patents,  
P.O. Box 1450, Alexandria, VA 22313-1450".*

/Shirley Winslow/  
Publication Branch  
Office of Data Management  
(571) 272-4200

**Application No. 14981290****APPLICATION FILED ON OR AFTER SEPTEMBER 16, 2012,  
NOT IN COMPLIANCE WITH 37 CFR 1.78**

- ☐ The 37 CFR 1.78(d)(2) reference on the application data sheet does not indicate the relationship (continuation, division, continuation-in-part) to the prior U.S. nonprovisional application or international application designating the U.S. See document coded dated , listing application number(s) .
- ☐ The 37 CFR 1.78(d)(2) reference on the application data sheet does not indicate the relationship (continuation, division, continuation-in-part) to the prior international application designating the U.S. but instead indicates that an application is the national stage of the prior international application. However, the application was filed as a 35 U.S.C. 111 application and was not processed as a 35 U.S.C. 371 application, thus removing the validating link under 35 U.S.C. 119(a)-(d) to a prior foreign application or under 35 U.S.C. 119(e) to a prior U.S. provisional application. See document coded dated , listing application number(s) .
- ☐ The 37 CFR 1.78(d)(2) reference on the application data sheet does not provide the U.S. nonprovisional application number (series code and serial number) or, with respect to an international PCT application designating the U.S., it provides the international application number or international filing date but not both. See document coded dated , in which the following is missing: .
- ☒ The 37 CFR 1.78(d)(2) reference on the application data sheet shows an incorrect, incomplete, or illegible U.S. nonprovisional application number, international PCT application number, or international PCT filing date. See document coded ADS dated 12/28/2015 , in which the following error was made: ADS p. 8 - 29/323,409 should be 29/323,408.
- ☐ The 37 CFR 1.78(d)(2) reference to the prior U.S. nonprovisional application or international application designating the U.S. is not present on an application data sheet, thus removing the validating link under 35 U.S.C. 119(a)-(d) to a prior foreign application or under 35 U.S.C. 119(e) to a prior U.S. provisional application. See document coded dated , in which the following is missing: .
- ☐ The 37 CFR 1.78(d)(2) reference to the prior U.S. nonprovisional application or international application designating the U.S. is not present on an application data sheet.
- ☐ The 37 CFR 1.78(a)(3) reference to the prior U.S. provisional application is not present on an application data sheet.
- ☐ The 37 CFR 1.78(a)(3) reference to the prior U.S. provisional application on an application data sheet does not provide the provisional application number (series code and serial number). See document coded dated , in which the following is missing: .
- ☐ The 37 CFR 1.78(a)(3) reference to the prior U.S. provisional application on an application data sheet shows an incorrect, incomplete, or illegible U.S. provisional application number. See document coded dated , in which the following error was made: .
- ☐ Other: .

**HOW TO RESPOND**

A proper response to this notice would include any one of: (1) a corrected Application Data Sheet (ADS) pursuant to 37 CFR 1.76(c) which provides benefit information that complies with 37 CFR 1.78(d)(2) or 37 CFR 1.78(a)(3) or (2) a petition filed pursuant to the provisions of 37 CFR 1.78(e) or 37 CFR 1.78(c) if the benefit information from the document identified above by code and date does not accurately reflect the benefits under 35 U.S.C. 119(e), 120, 121, 365(c) or 386(c) as claimed by applicant (a grantable petition would include a corrected ADS pursuant to 37 CFR 1.76(c)). In general, a petition would be required unless the proper benefit claim information was included on a properly signed ADS submitted with the application on filing, or a properly signed corrected ADS in compliance with 37 CFR 1.76(c) (e.g., with underlining to show insertions) that was filed within the time period in 37 CFR 1.78 for making the benefit claim(s), or the Office recognized the benefit claim(s) on the initial filing receipt. Such response may be filed after payment of the issue fee if limited to informalities noted herein. See Waiver of 37 CFR 1.312 for Document Required by Office of Patent Publication, 1280 Off. Gaz. Patent Office 918 (March 23, 2004).

**WARNING:** If Applicant fails to timely submit a proper response, the benefit information will be deleted and the patent will be printed without the benefit information present.

CX-1623



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/981,290	12/28/2015	Jeroen Poeze	MASCEP.002C2	9573
64735 7590 03/12/2019 KNOBBE, MARTENS, OLSON & BEAR, LLP MASIMO CORPORATION (MASIMO) 2040 MAIN STREET FOURTEENTH FLOOR IRVINE, CA 92614			EXAMINER LIU, CHU CHUAN	
			ART UNIT	PAPER NUMBER
			3791	
			NOTIFICATION DATE	DELIVERY MODE
			03/12/2019	ELECTRONIC

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jayna.cartee@knobbe.com  
 efiling@knobbe.com



UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents  
United States Patent and Trademark Office  
P.O. Box 1450  
Alexandria, VA 22313-1450  
www.uspto.gov

Application No. : 14981290

Applicant : Poeze

Filing Date : 12/28/2015

Date Mailed : 03/12/2019

## NOTICE TO FILE CORRECTED APPLICATION PAPERS

### *Notice of Allowance Mailed*

This application has been accorded an Allowance Date and is being prepared for issuance. The application, however, is incomplete for the reasons below.

**Applicant is given two (2) months from the mail date of this Notice within which to respond. This time period for reply is extendable under 37 CFR 1.136(a) for only TWO additional MONTHS.**

The application is not in compliance with 37 CFR 1.78, as indicated in the attachment. The consequences of failure to respond within the above-identified time period are set forth in the attachment.

Even if the Office has recognized a benefit claim and has entered it into the Office's database and included it on applicant's filing receipt, the benefit claim is not a proper benefit claim unless the reference in compliance with 37 CFR 1.78 is included, depending upon the application's filing date and as indicated in the attachment, in an application data sheet or in the first sentence(s) of the specification and all other requirements are met.

**See attachment.**

*A copy of this notice **MUST** be returned with the reply. Please address response to  
"Mail Stop Issue Fee, Commissioner for Patents,  
P.O. Box 1450, Alexandria, VA 22313-1450".*

/Shirley Winslow/  
Publication Branch  
Office of Data Management  
(571) 272-4200



**Application No. 14981290****APPLICATION FILED ON OR AFTER SEPTEMBER 16, 2012,  
NOT IN COMPLIANCE WITH 37 CFR 1.78**

- ☐ The 37 CFR 1.78(d)(2) reference on the application data sheet does not indicate the relationship (continuation, division, continuation-in-part) to the prior U.S. nonprovisional application or international application designating the U.S. See document coded dated , listing application number(s) .
- ☐ The 37 CFR 1.78(d)(2) reference on the application data sheet does not indicate the relationship (continuation, division, continuation-in-part) to the prior international application designating the U.S. but instead indicates that an application is the national stage of the prior international application. However, the application was filed as a 35 U.S.C. 111 application and was not processed as a 35 U.S.C. 371 application, thus removing the validating link under 35 U.S.C. 119(a)-(d) to a prior foreign application or under 35 U.S.C. 119(e) to a prior U.S. provisional application. See document coded dated , listing application number(s) .
- ☐ The 37 CFR 1.78(d)(2) reference on the application data sheet does not provide the U.S. nonprovisional application number (series code and serial number) or, with respect to an international PCT application designating the U.S., it provides the international application number or international filing date but not both. See document coded dated , in which the following is missing: .
- ☒ The 37 CFR 1.78(d)(2) reference on the application data sheet shows an incorrect, incomplete, or illegible U.S. nonprovisional application number, international PCT application number, or international PCT filing date. See document coded ADS dated 12/28/2015 , in which the following error was made: ADS p. 8 - 29/323,409 should be 29/323,408.
- ☐ The 37 CFR 1.78(d)(2) reference to the prior U.S. nonprovisional application or international application designating the U.S. is not present on an application data sheet, thus removing the validating link under 35 U.S.C. 119(a)-(d) to a prior foreign application or under 35 U.S.C. 119(e) to a prior U.S. provisional application. See document coded dated , in which the following is missing: .
- ☐ The 37 CFR 1.78(d)(2) reference to the prior U.S. nonprovisional application or international application designating the U.S. is not present on an application data sheet.
- ☐ The 37 CFR 1.78(a)(3) reference to the prior U.S. provisional application is not present on an application data sheet.
- ☐ The 37 CFR 1.78(a)(3) reference to the prior U.S. provisional application on an application data sheet does not provide the provisional application number (series code and serial number). See document coded dated , in which the following is missing: .
- ☐ The 37 CFR 1.78(a)(3) reference to the prior U.S. provisional application on an application data sheet shows an incorrect, incomplete, or illegible U.S. provisional application number. See document coded dated , in which the following error was made: .
- ☐ Other: .

**HOW TO RESPOND**

A proper response to this notice would include any one of: (1) a corrected Application Data Sheet (ADS) pursuant to 37 CFR 1.76(c) which provides benefit information that complies with 37 CFR 1.78(d)(2) or 37 CFR 1.78(a)(3) or (2) a petition filed pursuant to the provisions of 37 CFR 1.78(e) or 37 CFR 1.78(c) if the benefit information from the document identified above by code and date does not accurately reflect the benefits under 35 U.S.C. 119(e), 120, 121, 365(c) or 386(c) as claimed by applicant (a grantable petition would include a corrected ADS pursuant to 37 CFR 1.76(c)). In general, a petition would be required unless the proper benefit claim information was included on a properly signed ADS submitted with the application on filing, or a properly signed corrected ADS in compliance with 37 CFR 1.76(c) (e.g., with underlining to show insertions) that was filed within the time period in 37 CFR 1.78 for making the benefit claim(s), or the Office recognized the benefit claim(s) on the initial filing receipt. Such response may be filed after payment of the issue fee if limited to informalities noted herein. See Waiver of 37 CFR 1.312 for Document Required by Office of Patent Publication, 1280 Off. Gaz. Patent Office 918 (March 23, 2004).

**WARNING:** If Applicant fails to timely submit a proper response, the benefit information will be deleted and the patent will be printed without the benefit information present.



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

## NOTICE OF ALLOWANCE AND FEE(S) DUE

64735 7590 02/11/2019  
 KNOBBE, MARTENS, OLSON & BEAR, LLP  
 MASIMO CORPORATION (MASIMO)  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

EXAMINER

LIU, CHU CHUAN

ART UNIT

PAPER NUMBER

3791

DATE MAILED: 02/11/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/981,290	12/28/2015	Jeroen Poeze	MASCER.002C2	9573

TITLE OF INVENTION: MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	05/13/2019

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

## HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at [www.uspto.gov/PatentMaintenanceFees](http://www.uspto.gov/PatentMaintenanceFees).**

CX-1623

**PART B - FEE(S) TRANSMITTAL**

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

**INSTRUCTIONS:** This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

64735 7590 02/11/2019  
KNOBBE, MARTENS, OLSON & BEAR, LLP  
MASIMO CORPORATION (MASIMO)  
2040 MAIN STREET  
FOURTEENTH FLOOR  
IRVINE, CA 92614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/981,290	12/28/2015	Jeroen Poeze	MASCER.002C2	9573

TITLE OF INVENTION: MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	05/13/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
LIU, CHU CHUAN	3791	600-322000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 \_\_\_\_\_  
2 \_\_\_\_\_  
3 \_\_\_\_\_

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies \_\_\_\_\_

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☐ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. \_\_\_\_\_

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

**NOTE:** Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

**NOTE:** If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

**NOTE:** Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

**NOTE:** This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature \_\_\_\_\_

Date \_\_\_\_\_

Typed or printed name \_\_\_\_\_

Registration No. \_\_\_\_\_



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
**United States Patent and Trademark Office**  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/981,290	12/28/2015	Jeroen Poeze	MASCER.002C2	9573
64735 7590 02/11/2019 <b>KNOBBE, MARTENS, OLSON &amp; BEAR, LLP</b> <b>MASIMO CORPORATION (MASIMO)</b> <b>2040 MAIN STREET</b> <b>FOURTEENTH FLOOR</b> <b>IRVINE, CA 92614</b>			<b>EXAMINER</b> LIU, CHU CHUAN	
			ART UNIT	PAPER NUMBER
			3791	
DATE MAILED: 02/11/2019				

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**  
 (Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

**OMB Clearance and PRA Burden Statement for PTOL-85 Part B**

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**Privacy Act Statement**

**The Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

<b>Notice of Allowability</b>	<b>Application No.</b> 14/981,290	<b>Applicant(s)</b> Poeze et al.	
	<b>Examiner</b> CHU CHUAN LIU	<b>Art Unit</b> 3791	<b>AIA Status</b> No

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--**

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to the response filed on 10/30/2018.  
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on \_\_\_\_\_.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on \_\_\_\_\_; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 12 and 15-19. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see [http://www.uspto.gov/patents/init\\_events/pph/index.jsp](http://www.uspto.gov/patents/init_events/pph/index.jsp) or send an inquiry to **PPHfeedback@uspto.gov**.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a) ☐ All      b) ☐ Some      \*c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

\* Certified copies not received: \_\_\_\_\_.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file areply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.  
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.  
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date \_\_\_\_\_.

**Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. <input type="checkbox"/> Notice of References Cited (PTO-892)	5. <input checked="" type="checkbox"/> Examiner's Amendment/Comment
2. <input checked="" type="checkbox"/> Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date <u>01/23/2019</u> .	6. <input checked="" type="checkbox"/> Examiner's Statement of Reasons for Allowance
3. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. <input type="checkbox"/> Other _____.
4. <input type="checkbox"/> Interview Summary (PTO-413), Paper No./Mail Date. _____.	

/CHU CHUAN LIU/ Examiner, Art Unit 3791	/ERIC F WINAKUR/ Primary Examiner, Art Unit 3791
--	---

Application/Control Number: 14/981,290  
Art Unit: 3791

Page 2

### EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in an interview with Scott Cromar on 01/24/2019. Amendments were made to better define over the art.

The application has been amended as follows:

Claim 12. A noninvasive physiological sensor comprising:

a front-end interface comprising:

one or more detectors, each detector including a respective set of photodiodes;

one or more inputs configured to receive signals from respective one or more detectors in the sensor;

a respective two ~~[[one]]~~ or more transimpedance amplifiers for each respective detector and configured to convert the signals from the respective sets of photodiodes ~~one or more detectors~~ into output signals for each of the respective sets of photodiodes ~~one or more detectors~~; and

a[[n]] respective averager, coupled to the respective ~~[[one]]~~ two or more transimpedance amplifiers for each respective detector, and

Application/Control Number: 14/981,290  
Art Unit: 3791

Page 3

configured to average the output signals from the respective ~~[[one]]~~ two or more transimpedance amplifiers into ~~the a respective single~~ output signal.

Claim 14 was cancelled.

Claim 15. The noninvasive physiological sensor of Claim ~~[[14]]~~ 12, wherein each ~~[[the]]~~ set of photodiodes comprises two photodiodes coupled together.

Claim 16. The noninvasive physiological sensor of Claim ~~[[14]]~~ 12, wherein each ~~[[the]]~~ set of photodiodes comprises three photodiodes coupled together.

Claim 17. The noninvasive physiological sensor of Claim ~~[[14]]~~ 12, wherein each ~~[[the]]~~ set of photodiodes comprises four photodiodes coupled together.

Claim 18. The noninvasive physiological sensor of Claim ~~[[14]]~~ 12, wherein each ~~[[the]]~~ set of photodiodes comprises nine photodiodes coupled together.

Claim 19. The noninvasive physiological sensor of Claim ~~[[14]]~~ 12, wherein each ~~[[the]]~~ set of photodiodes coupled together provides a detection area of approximately 1 mm<sup>2</sup>.



Application/Control Number: 14/981,290  
Art Unit: 3791

Page 4

***Reasons for Allowance***

2. The following is an examiner's statement of reasons for allowance: Dettling (UPSN 6,360,113 – cited in previous action) teaches an oximeter comprises a detector, including a respective set of photodiodes (DD1 and DD2. Figs. 1-4 and associated descriptions); a respective two transimpedance amplifiers (elements 301 and 303, Fig. 3B) configured to convert the signals from the respective photodiodes into output signals (output signals from elements 301 and 303, Fig. 3B) and a summing amplifier (element 305, Fig. 3B) configured to sum the output signals from the TIAs. Wilcken et al. (USPGPUB 2006/0076473 – cited in previous action) teaches a detector assembly comprises a detector including four photodiodes (Fig. 4) and each photodiode is coupled to a TIA (Fig. 4) and a summing amplifier is configured to sum the output signals from each TIA into one output signal (Fig. 4). The prior art of record does not teach or suggest "a respective two or more transimpedance amplifiers for each respective detector and configured to convert the signals from the respective sets of photodiodes into output signals for each of the respective sets of photodiodes; and a respective averager, coupled to the respective two or more transimpedance amplifiers for each respective detector, and configured to average the output signals from the respective two or more transimpedance amplifiers into a respective output signal", in combination with the other claimed elements/steps.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Application/Control Number: 14/981,290  
Art Unit: 3791

Page 5

### ***Conclusion***

3. Any inquiry concerning this communication or earlier communications from the examiner should be directed to CHU CHUAN LIU whose telephone number is (571)270-5507. The examiner can normally be reached on M-Th (8am-6pm).

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jacqueline Cheng can be reached on (571) 272-5596. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a

Application/Control Number: 14/981,290  
Art Unit: 3791


Page 6

USPTO Customer Service Representative or access to the automated information  
system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/ERIC F WINAKUR/  
Primary Examiner, Art Unit 3791

/CHU CHUAN LIU/  
Examiner, Art Unit 3791

CX-1623

<b>Issue Classification</b> 	<b>Application/Control No.</b> 14/981,290	<b>Applicant(s)/Patent Under Reexamination</b> Poeze et al.
	<b>Examiner</b> CHU CHUAN LIU	<b>Art Unit</b> 3791

CPC						
Symbol					Type	Version
A61B	/	5	/	1455	F	2013-01-01
A61B	/	5	/	14532	I	2013-01-01
A61B	/	5	/	14546	I	2013-01-01
A61B	/	5	/	14552	I	2013-01-01
A61B	/	5	/	6816	I	2013-01-01
A61B	/	5	/	6826	I	2013-01-01
A61B	/	5	/	6829	I	2013-01-01
A61B	/	5	/	6838	I	2013-01-01
A61B	/	5	/	6843	I	2013-01-01
A61B	/	2562	/	0233	A	2013-01-01
A61B	/	2562	/	046	A	2013-01-01
A61B	/	2562	/	146	A	2013-01-01
A61B	/	2562	/	04	A	2013-01-01


CPC Combination Sets				
Symbol	Type	Set	Ranking	Version
/				

/CHU CHUAN LIU/ Examiner, Art Unit 3791 (Assistant Examiner)	24 January 2019 (Date)	<b>Total Claims Allowed:</b> 6	
/ERIC F WINAKUR/ Primary Examiner, Art Unit 3791 (Primary Examiner)	25 January 2019 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 15J

U.S. Patent and Trademark Office

Part of Paper No.: 20190124

CX-1623

<b>Issue Classification</b> 	<b>Application/Control No.</b> 14/981,290	<b>Applicant(s)/Patent Under Reexamination</b> Poeze et al.
	<b>Examiner</b> CHU CHUAN LIU	<b>Art Unit</b> 3791

<b>INTERNATIONAL CLASSIFICATION</b>			
<b>CLAIMED</b>			
A61B		5	1455
<b>NON-CLAIMED</b>			

<b>US ORIGINAL CLASSIFICATION</b>	
<b>CLASS</b>	<b>SUBCLASS</b>


<b>CROSS REFERENCES(S)</b>						
<b>CLASS</b>	<b>SUBCLASS (ONE SUBCLASS PER BLOCK)</b>					

/CHU CHUAN LIU/ Examiner, Art Unit 3791 (Assistant Examiner)	24 January 2019 (Date)	<b>Total Claims Allowed:</b> 6	
/ERIC F WINAKUR/ Primary Examiner, Art Unit 3791 (Primary Examiner)	25 January 2019 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 15J

U.S. Patent and Trademark Office

Part of Paper No.: 20190124

CX-1623

<b>Issue Classification</b> 	<b>Application/Control No.</b> 14/981,290	<b>Applicant(s)/Patent Under Reexamination</b> Poeze et al.
	<b>Examiner</b> CHU CHUAN LIU	<b>Art Unit</b> 3791


<input type="checkbox"/> Claims renumbered in the same order as presented by applicant <input type="checkbox"/> CPA <input type="checkbox"/> T.D. <input type="checkbox"/> R.1.47															
<b>CLAIMS</b>															
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		10	6	19										
	2		11												
	3	1	12												
	4		13												
	5		14												
	6	2	15												
	7	3	16												
	8	4	17												
	9	5	18												

/CHU CHUAN LIU/ Examiner, Art Unit 3791 (Assistant Examiner)	24 January 2019 (Date)	<b>Total Claims Allowed:</b> 6	
/ERIC F WINAKUR/ Primary Examiner, Art Unit 3791 (Primary Examiner)	25 January 2019 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 15J

U.S. Patent and Trademark Office

Part of Paper No.: 20190124

CX-1623

<b><i>Search Notes</i></b> 	<b>Application/Control No.</b> 14/981,290	<b>Applicant(s)/Patent Under Reexamination</b> Poeze et al.
	<b>Examiner</b> CHU CHUAN LIU	<b>Art Unit</b> 3791

CPC - Searched*		
Symbol	Date	Examiner
A61B5/0205,1455,14551,14552,14532,72,7225	7/2/2018	CCL
A61B5/0205,1455,14551,14552,14532,14546,6816,6826,6829,6838,6843,72,7225	01/24/2019	CCL

CPC Combination Sets - Searched*		
Symbol	Date	Examiner


US Classification - Searched*			
Class	Subclass	Date	Examiner

\* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Inventor Name Search (PALM and EAST)	7/2/2018	CCL
EAST Search (TEXT, USPGPUB, USPAT, CPC) See Search History	7/2/2018	CCL
Google NPL Search	7/2/2018	CCL
Updated EAST Search (TEXT, USPGPUB, USPAT, CPC) See Search History	01/24/2019	CCL
Google NPL Search	01/24/2019	CCL
Allowance consultation with Eric Winakur	01/24/2019	CCL

	/CHU CHUAN LIU/ Examiner, Art Unit 3791
--	--

CX-1623

<b><i>Search Notes</i></b> 	<b>Application/Control No.</b> 14/981,290	<b>Applicant(s)/Patent Under Reexamination</b> Poeze et al.
	<b>Examiner</b> CHU CHUAN LIU	<b>Art Unit</b> 3791

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
A61B5	0205,1455,14551,14552,14532,14546,6816,6826,6829,6838,6843,72,7225	01/24/2019	CCL

	/CHU CHUAN LIU/ Examiner, Art Unit 3791
--	--



## EAST Search History

## EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S65	14	"6360113" and transimpedance	US-PGPUB; USPAT	OR	ON	2019/01/24 11:23
S64	50	transimpedance with amplifier same averag\$3 and (600/310-344.ccls. A61B5/0205,1455,14551,14552,14532,14546,6816,6826,6829,6838,6843,72,7225.cpc.)	US-PGPUB; USPAT	OR	ON	2019/01/24 11:13
S63	104	("10039080"   "10055121"   "10066970"   "10076257"   "10078052"   "20140171146"   "20150173671"   "20150255001"   "20150281424"   "20150318100"   "20160019360"   "20160023245"   "20160038045"   "20160051157"   "20160051158"   "20160058302"   "20160058309"   "20160058312"   "20160058356"   "20160058370"   "20160071392"   "20160154950"   "20160157780"   "20160213309"   "20160256058"   "20160256082"   "20160287181"   "20160296173"   "20160296174"   "20160310027"   "20160378069"   "20160378071"   "20170007183"   "20170010858"   "20170074897"   "20170084133"   "20170086689"   "20170086742"   "20170086743"   "20170094450"   "20170164884"   "20170248446"   "20170273619"   "20170281024"   "20170293727"   "20170325698"   "20170325744"   "20170340209"   "20170340219"   "20170347885"   "20170354332"   "20170354795"   "20170358239"   "20170358240"   "20170360306"   "20170366657"   "20180014781"   "20180025287"   "20180042556"   "20180049694"   "20180050235"   "20180055375"   "20180055439"   "20180056129"   "20180078151"   "20180078182"   "20180110469"   "20180153418"   "20180164853"   "20180196514"   "20180228414"   "20180238734"   "20180279956"   "7519327"   "7601123"   "7726209"   "7862523"   "8289130"   "8364389"   "8615290"   "8655004"   "8760517"   "9072437"   "9081889"   "9210566"   "9311382"   "9357665"   "9489081"   "9497534"   "9526430"   "9553625"   "9593969"   "9651405"   "9668676"   "9699546"   "9716937"   "9723997"   "9781984"   "9838775"   "9848823"   "9866671"   "9867575"   "9918646"   "9952095").PN.	US-PGPUB; USPAT	OR	ON	2019/01/24 11:09
S62	1	("20080139908").PN.	US-PGPUB; USPAT	OR	OFF	2019/01/22 13:24
S61	1	("20080078592").PN.	US-PGPUB; USPAT	OR	OFF	2019/01/22 13:23
S60	11	S58 and transimpedance.clm. with amplifier	US-PGPUB; USPAT	OR	ON	2019/01/22 13:21
S59	90	S58 and transimpedance with amplifier	US-PGPUB; USPAT	OR	ON	2019/01/22 13:18
S58	872	(Poeze near2 Jeroen Lamego near2 Marcelo Merritt near2 Sean Dalvi near2 Cristiano Vo near2 Hung Bruinsma near2 Johannes Lesmana near2 Ferdyan Kiani near3 Massi with Joe).in. MASIMO.as.	US-PGPUB; USPAT	OR	ON	2019/01/22 13:18
S57	91	low\$1pass adj filter\$3 with averag\$3 and A61B5/14551,72.cpc.	US-PGPUB; USPAT	OR	ON	2019/01/22 13:06
S56	250	photodiode\$1 and (transimpedance adj amplifier TIA) with averag\$3	US-PGPUB; USPAT	OR	ON	2019/01/22 12:52
S55	127	photodiodes and transimpedance adj amplifier with averag\$3	US-PGPUB; USPAT	OR	ON	2019/01/22 12:50
S54	127	photodiode\$1 and transimpedance adj amplifier with averag\$3	US-PGPUB; USPAT	OR	ON	2019/01/22 12:46
S53	1	("20090306487").PN.	US-PGPUB; USPAT	OR	OFF	2019/01/22 12:40
S52	4	"12534812"	US-PGPUB; USPAT	OR	ON	2019/01/22 12:27
S51	1	("20090030327").PN.	US-PGPUB;	OR	OFF	2019/01/22 12:23

EAST Search History

CX-1623

			USPAT			
S50	1	("20110105865").PN.	US-PGPUB; USPAT	OR	OFF	2019/01/22 12:21
S49	9	low\$1pass adj filter\$3 with averag\$3 with effect and ("600".clas. 356/41.ccls. A61B5/1455.cpc.)	US-PGPUB; USPAT	OR	ON	2019/01/22 11:57
S48	362	low\$1pass adj filter\$3 with averag\$3 with effect	US-PGPUB; USPAT	OR	ON	2019/01/22 11:48
S47	557	low\$1pass adj filter\$3 with averag\$3 and "600".clas.	US-PGPUB; USPAT	OR	ON	2019/01/22 11:43
S46	83	low\$1pass adj filter\$3 with averag\$3 and 600/310-344.ccls.	US-PGPUB; USPAT	OR	ON	2019/01/22 11:30
S45	1	("6360113").PN.	US-PGPUB; USPAT	OR	OFF	2019/01/22 10:48

**EAST Search History (Interference)**

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S67	50	transimpedance with amplifier same averag\$3 and (600/310-344.ccls. A61B5/0205,1455,14551,14552,14532,14546,6816,6826,6829,6838,6843,72,7225.cpc.)	US-PGPUB; USPAT	OR	ON	2019/01/24 11:12
S66	47	transimpedance with amplifier same averag\$3 and (600/310-344.ccls. A61B5/0205,1455,14551,14552,14532,72,7225.cpc.)	US-PGPUB; USPAT	OR	ON	2019/01/24 11:10

1/ 24/ 2019 1:58:51 PM

C:\Users\cliu\Documents\EAST\Workspaces\14981290.wsp

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 1 OF 4	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	7,519,327	04-14-2009	White	
	2	7,601,123	10-13-2009	Tweed, et al.	
	3	7,726,209	06-01-2010	Ruotoistenmäki	
	4	7,862,523	01-04-2011	Ruotoistenmaki	
	5	8,289,130	10-16-2012	Nakajima et al.	
	6	8,364,389	01-29-2013	Dorogusker et al.	
	7	8,615,290	12-24-2013	Lin et al.	
	8	8,655,004	02-18-2014	Prest et al.	
	9	8,760,517	06-24-2014	Sarwar et al.	
	10	9,072,437	07-07-2015	Paalasmaa	
	11	9,081,889	07-14-2015	Ingrassia, Jr. et al.	
	12	9,210,566	12-08-2015	Ziemianska et al.	
	13	9,311,382	04-12-2016	Varoglu et al.	
	14	9,357,665	05-31-2016	Myers et al.	
	15	9,489,081	11-08-2016	Anzures et al.	
	16	9,497,534	11-15-2016	Prest et al.	
	17	9,526,430	12-27-2016	Srinivas et al.	
	18	9,553,625	01-24-2017	Hatanaka et al.	
	19	9,593,969	03-14-2017	King	
	20	9,651,405	05-16-2017	Gowreesunker et al.	
	21	9,668,676	06-06-2017	Culbert	
	22	9,699,546	07-04-2017	Qian et al.	
	23	9,716,937	07-25-2017	Qian et al.	
	24	9,723,997	08-08-2017	Lamego	
	25	9,781,984	10-10-2017	Baranski et al.	
	26	9,838,775	12-05-2017	Qian et al.	
	27	9,848,823	12-26-2017	Raghuram et al.	
	28	9,866,671	01-09-2018	Thompson et al.	
	29	9,867,575	01-16-2018	Maani et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59466**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 2 OF 4	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	9,898,049	02-20-2018	Myers et al.	
	31	9,918,646	03-20-2018	Singh Alvarado et al.	
	32	9,952,095	04-24-2018	Hotelling et al.	
	33	10,039,080	07-31-2018	Miller et al.	
	34	10,055,121	08-21-2018	Chaudhri et al.	
	35	10,066,970	09-04-2018	Gowreesunker et al.	
	36	10,076,257	09-18-2018	Lin et al.	
	37	10,078,052	09-18-2018	Ness et al.	
	38	2014/0171146	06-19-2014	Ma et al.	
	39	2015/0173671	06-25-2015	Paalasmaa et al.	
	40	2015/0255001	09-10-2015	Haughav et al.	
	41	2015/0281424	10-01-2015	Vock et al.	
	42	2015/0318100	11-05-2015	Rothkopf et al.	
	43	2016/0019360	01-21-2016	Pahwa et al.	
	44	2016/0023245	01-28-2016	Zadesky et al.	
	45	2016/0038045	02-11-2016	Shapiro	
	46	2016/0051157	02-25-2016	Waydo	
	47	2016/0051158	02-25-2016	Silva	
	48	2016/0058302	03-03-2016	Raghuram et al.	
	49	2016/0058309	03-03-2016	Han	
	50	2016/0058312	03-03-2016	Han et al.	
	51	2016/0058356	03-03-2016	Raghuram et al.	
	52	2016/0058370	03-03-2016	Raghuram et al.	
	53	2016/0071392	03-10-2016	Hankey et al.	
	54	2016/0154950	06-02-2016	Nakajima et al.	
	55	2016/0157780	06-09-2016	Rimminen et al.	
	56	2016/0213309	07-28-2016	Sannholm et al.	
	57	2016/0256058	09-08-2016	Pham et al.	
	58	2016/0256082	09-08-2016	Ely et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59467**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 3 OF 4	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	2016/0267238	09-15-2016	Nag	
	60	2016/0287181	10-06-2016	Han et al.	
	61	2016/0296173	10-13-2016	Culbert	
	62	2016/0296174	10-13-2016	Isikman et al.	
	63	2016/0310027	10-27-2016	Han	
	64	2016/0378069	12-29-2016	Rothkopf	
	65	2016/0378071	12-29-2016	Rothkopf	
	66	2017/0007183	01-12-2017	Dusan et al.	
	67	2017/0010858	01-12-2017	Prest et al.	
	68	2017/0074897	03-16-2017	Mermel et al.	
	69	2017/0084133	03-23-2017	Cardinali et al.	
	70	2017/0086689	03-30-2017	Shui et al.	
	71	2017/0086742	03-30-2017	Harrison-Noonan et al.	
	72	2017/0086743	03-30-2017	Bushnell et al.	
	73	2017/0094450	03-30-2017	Tu et al.	
	74	2017/0164884	06-15-2017	Culbert et al.	
	75	2017/0248446	08-31-2017	Gowreesunker et al.	
	76	2017/0273619	09-28-2017	Alvarado et al.	
	77	2017/0281024	10-05-2017	Narasimhan et al.	
	78	2017/0293727	10-12-2017	Klaassen et al.	
	79	2017/0325698	11-16-2017	Allec et al.	
	80	2017/0325744	11-16-2017	Allec et al.	
	81	2017/0340209	11-30-2017	Klaassen et al.	
	82	2017/0340219	11-30-2017	Sullivan et al.	
	83	2017/0347885	12-07-2017	Tan et al.	
	84	2017/0354332	12-14-2017	Lamego	
	85	2017/0354795	12-14-2017	Blahnik et al.	
	86	2017/0358239	12-14-2017	Arney et al.	
	87	2017/0358240	12-14-2017	Blahnik et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59468**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
(Multiple sheets used when necessary)	Examiner	Liu, Chu Chuan
SHEET 4 OF 4	Attorney Docket No.	MASCER.002C2

## U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	2017/0358242	12-14-2017	Thompson et al.	
	89	2017/0360306	12-14-2017	Narasimhan et al.	
	90	2017/0366657	12-21-2017	Thompson et al.	
	91	2018/0014781	01-18-2018	Clavelle et al.	
	92	2018/0025287	01-25-2018	Mathew et al.	
	93	2018/0042556	02-15-2018	Shahparnia et al.	
	94	2018/0049694	02-22-2018	Singh Alvarado et al.	
	95	2018/0050235	02-22-2018	Tan et al.	
	96	2018/0055375	03-01-2018	Martinez et al.	
	97	2018/0055439	03-01-2018	Pham et al.	
	98	2018/0056129	01-01-2018	Narasimha Rao et al.	
	99	2018/0078151	03-22-2018	Allec et al.	
	100	2018/0078182	03-22-2018	Chen et al.	
	101	2018/0110469	04-26-2018	Maani et al.	
	102	2018/0153418	06-07-2018	Sullivan et al.	
	103	2018/0164853	06-14-2018	Myers et al.	
	104	2018/0196514	07-12-2018	Allec et al.	
	105	2018/0228414	08-16-2018	Shao et al.	
	106	2018/0238734	08-23-2018	Hotelling et al.	
	107	2018/0279956	10-04-2018	Waydo et al.	

## FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document Country Code-Number-Kind Code Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T <sup>1</sup>
-------------------	----------	--	--------------------------------	------	--	----------------

## NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
-------------------	----------	---	----------------

Examiner Signature	/CHU CHUAN LIU/	Date Considered	01/24/2019
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.			

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Bibliographic Data**

Application No: 14/981,290

Foreign Priority claimed: ☐ Yes ☒ No35 USC 119 (a-d) conditions met: ☐ Yes ☒ No ☐ Met After Allowance

Verified and Acknowledged:

/CHU CHUAN LIU/

Examiner's Signature

Initials

Title:

MULTI-STREAM DATA COLLECTION SYSTEM FOR  
NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

---

<b>FILING or 371(c) DATE</b>	<b>CLASS</b>	<b>GROUP ART UNIT</b>	<b>ATTORNEY DOCKET NO.</b>
12/28/2015	600	3791	MASCER.002C2
<b>RULE</b>			

**APPLICANTS**

MASIMO CORPORATION, Irvine, CA, UNITED STATES

**INVENTORS**

Jeroen Poeze Rancho Santa Margarita, CA, UNITED STATES

Marcelo Lamego Cupertino, CA, UNITED STATES

Sean Merritt Lake Forest, CA, UNITED STATES

Cristiano Dalvi Lake Forest, CA, UNITED STATES

Hung Vo Fountain Valley, CA, UNITED STATES

Johannes Bruinsma Opeinde, NETHERLANDS

Ferdyan Lesmana Irvine, CA, UNITED STATES

Massi Joe E. Kiani Laguna Niguel, CA, UNITED STATES

**CONTINUING DATA**

This application is a CON of 12829352 07/01/2010 PAT 9277880

12829352 is a CON of 12534827 08/03/2009ABN

12829352 is a CIP of 12497523 07/02/2009 PAT 8437825

12829352 is a CIP of 12497528 07/02/2009 PAT 8577431

12497528 is a CIP of 29323409 08/25/2008 PAT D621516

12497523 is a CIP of 29323408 08/25/2008 PAT D606659

12497523 is a CIP of 29323409 08/25/2008 PAT D621516

12534827 has PRO of 61091732 08/25/2008

12497528 has PRO of 61091732 08/25/2008

12497523 has PRO of 61091732 08/25/2008

12497528 is a CIP of 29323408 08/25/2008 PAT D606659

12497523 has PRO of 61086060 08/04/2008  
12497528 has PRO of 61086057 08/04/2008  
12534827 has PRO of 61086108 08/04/2008  
12497523 has PRO of 61086057 08/04/2008  
12497523 has PRO of 61086063 08/04/2008  
12497528 has PRO of 61086063 08/04/2008  
12497523 has PRO of 61086108 08/04/2008  
12497528 has PRO of 61086108 08/04/2008  
12497528 has PRO of 61086060 08/04/2008  
12534827 has PRO of 61086057 08/04/2008  
12534827 has PRO of 61086060 08/04/2008  
12534827 has PRO of 61086063 08/04/2008  
12497528 has PRO of 61078228 07/03/2008  
12497523 has PRO of 61078228 07/03/2008  
12497528 has PRO of 61078207 07/03/2008  
12497523 has PRO of 61078207 07/03/2008

**FOREIGN APPLICATIONS**

**IF REQUIRED, FOREIGN LICENSE GRANTED\*\***

01/14/2016

**STATE OR COUNTRY**

UNITED STATES

**ADDRESS**

KNOBBE, MARTENS, OLSON & BEAR, LLP  
MASIMO CORPORATION (MASIMO)  
2040 MAIN STREET  
FOURTEENTH FLOOR  
IRVINE, CA 92614  
UNITED STATES

**FILING FEE RECEIVED**

\$1,740



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 1 OF 4	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	7,519,327	04-14-2009	White	
	2	7,601,123	10-13-2009	Tweed, et al.	
	3	7,726,209	06-01-2010	Ruotoistenmäki	
	4	7,862,523	01-04-2011	Ruotoistenmaki	
	5	8,289,130	10-16-2012	Nakajima et al.	
	6	8,364,389	01-29-2013	Dorogusker et al.	
	7	8,615,290	12-24-2013	Lin et al.	
	8	8,655,004	02-18-2014	Prest et al.	
	9	8,760,517	06-24-2014	Sarwar et al.	
	10	9,072,437	07-07-2015	Paalasmaa	
	11	9,081,889	07-14-2015	Ingrassia, Jr. et al.	
	12	9,210,566	12-08-2015	Ziemianska et al.	
	13	9,311,382	04-12-2016	Varoglu et al.	
	14	9,357,665	05-31-2016	Myers et al.	
	15	9,489,081	11-08-2016	Anzures et al.	
	16	9,497,534	11-15-2016	Prest et al.	
	17	9,526,430	12-27-2016	Srinivas et al.	
	18	9,553,625	01-24-2017	Hatanaka et al.	
	19	9,593,969	03-14-2017	King	
	20	9,651,405	05-16-2017	Gowreesunker et al.	
	21	9,668,676	06-06-2017	Culbert	
	22	9,699,546	07-04-2017	Qian et al.	
	23	9,716,937	07-25-2017	Qian et al.	
	24	9,723,997	08-08-2017	Lamego	
	25	9,781,984	10-10-2017	Baranski et al.	
	26	9,838,775	12-05-2017	Qian et al.	
	27	9,848,823	12-26-2017	Raghuram et al.	
	28	9,866,671	01-09-2018	Thompson et al.	
	29	9,867,575	01-16-2018	Maani et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
(Multiple sheets used when necessary)	Examiner	Liu, Chu Chuan
SHEET 2 OF 4	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	9,898,049	02-20-2018	Myers et al.	
	31	9,918,646	03-20-2018	Singh Alvarado et al.	
	32	9,952,095	04-24-2018	Hotelling et al.	
	33	10,039,080	07-31-2018	Miller et al.	
	34	10,055,121	08-21-2018	Chaudhri et al.	
	35	10,066,970	09-04-2018	Gowreesunker et al.	
	36	10,076,257	09-18-2018	Lin et al.	
	37	10,078,052	09-18-2018	Ness et al.	
	38	2014/0171146	06-19-2014	Ma et al.	
	39	2015/0173671	06-25-2015	Paalasmaa et al.	
	40	2015/0255001	09-10-2015	Haughav et al.	
	41	2015/0281424	10-01-2015	Vock et al.	
	42	2015/0318100	11-05-2015	Rothkopf et al.	
	43	2016/0019360	01-21-2016	Pahwa et al.	
	44	2016/0023245	01-28-2016	Zadesky et al.	
	45	2016/0038045	02-11-2016	Shapiro	
	46	2016/0051157	02-25-2016	Waydo	
	47	2016/0051158	02-25-2016	Silva	
	48	2016/0058302	03-03-2016	Raghuram et al.	
	49	2016/0058309	03-03-2016	Han	
	50	2016/0058312	03-03-2016	Han et al.	
	51	2016/0058356	03-03-2016	Raghuram et al.	
	52	2016/0058370	03-03-2016	Raghuram et al.	
	53	2016/0071392	03-10-2016	Hankey et al.	
	54	2016/0154950	06-02-2016	Nakajima et al.	
	55	2016/0157780	06-09-2016	Rimminen et al.	
	56	2016/0213309	07-28-2016	Sannholm et al.	
	57	2016/0256058	09-08-2016	Pham et al.	
	58	2016/0256082	09-08-2016	Ely et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 3 OF 4	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	2016/0267238	09-15-2016	Nag	
	60	2016/0287181	10-06-2016	Han et al.	
	61	2016/0296173	10-13-2016	Culbert	
	62	2016/0296174	10-13-2016	Isikman et al.	
	63	2016/0310027	10-27-2016	Han	
	64	2016/0378069	12-29-2016	Rothkopf	
	65	2016/0378071	12-29-2016	Rothkopf	
	66	2017/0007183	01-12-2017	Dusan et al.	
	67	2017/0010858	01-12-2017	Prest et al.	
	68	2017/0074897	03-16-2017	Mermel et al.	
	69	2017/0084133	03-23-2017	Cardinali et al.	
	70	2017/0086689	03-30-2017	Shui et al.	
	71	2017/0086742	03-30-2017	Harrison-Noonan et al.	
	72	2017/0086743	03-30-2017	Bushnell et al.	
	73	2017/0094450	03-30-2017	Tu et al.	
	74	2017/0164884	06-15-2017	Culbert et al.	
	75	2017/0248446	08-31-2017	Gowreesunker et al.	
	76	2017/0273619	09-28-2017	Alvarado et al.	
	77	2017/0281024	10-05-2017	Narasimhan et al.	
	78	2017/0293727	10-12-2017	Klaassen et al.	
	79	2017/0325698	11-16-2017	Allec et al.	
	80	2017/0325744	11-16-2017	Allec et al.	
	81	2017/0340209	11-30-2017	Klaassen et al.	
	82	2017/0340219	11-30-2017	Sullivan et al.	
	83	2017/0347885	12-07-2017	Tan et al.	
	84	2017/0354332	12-14-2017	Lamego	
	85	2017/0354795	12-14-2017	Blahnik et al.	
	86	2017/0358239	12-14-2017	Arney et al.	
	87	2017/0358240	12-14-2017	Blahnik et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
(Multiple sheets used when necessary)	Examiner	Liu, Chu Chuan
SHEET 4 OF 4	Attorney Docket No.	MASCER.002C2

## U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	2017/0358242	12-14-2017	Thompson et al.	
	89	2017/0360306	12-14-2017	Narasimhan et al.	
	90	2017/0366657	12-21-2017	Thompson et al.	
	91	2018/0014781	01-18-2018	Clavelle et al.	
	92	2018/0025287	01-25-2018	Mathew et al.	
	93	2018/0042556	02-15-2018	Shahparnia et al.	
	94	2018/0049694	02-22-2018	Singh Alvarado et al.	
	95	2018/0050235	02-22-2018	Tan et al.	
	96	2018/0055375	03-01-2018	Martinez et al.	
	97	2018/0055439	03-01-2018	Pham et al.	
	98	2018/0056129	01-01-2018	Narasimha Rao et al.	
	99	2018/0078151	03-22-2018	Allec et al.	
	100	2018/0078182	03-22-2018	Chen et al.	
	101	2018/0110469	04-26-2018	Maani et al.	
	102	2018/0153418	06-07-2018	Sullivan et al.	
	103	2018/0164853	06-14-2018	Myers et al.	
	104	2018/0196514	07-12-2018	Allec et al.	
	105	2018/0228414	08-16-2018	Shao et al.	
	106	2018/0238734	08-23-2018	Hotelling et al.	
	107	2018/0279956	10-04-2018	Waydo et al.	

## FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document Country Code-Number-Kind Code Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T <sup>1</sup>
-------------------	----------	--	--------------------------------	------	--	----------------

## NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
-------------------	----------	---	----------------

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

Electronic Patent Application Fee Transmittal				
<b>Application Number:</b>		14981290		
<b>Filing Date:</b>		28-Dec-2015		
<b>Title of Invention:</b>		MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
<b>First Named Inventor/Applicant Name:</b>		Jeroen Poeze		
<b>Filer:</b>		Scott Cromar/Frances Tsai		
<b>Attorney Docket Number:</b>		MASCER.002C2		
Filed as Large Entity				
<b>Filing Fees for Utility under 35 USC 111(a)</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent-Appeals-and-Interference:</b>				
<b>Post-Allowance-and-Post-Issuance:</b>				
<b>Extension-of-Time:</b>				

CX-1623

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
<b>Miscellaneous:</b>				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	240	240
<b>Total in USD (\$)</b>				<b>240</b>

CX-1623

<b>Electronic Acknowledgement Receipt</b>	
<b>EFS ID:</b>	34934721
<b>Application Number:</b>	14981290
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9573
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	64735
<b>Filer:</b>	Scott Cromar/Sandra Autry
<b>Filer Authorized By:</b>	Scott Cromar
<b>Attorney Docket Number:</b>	MASCER.002C2
<b>Receipt Date:</b>	23-JAN-2019
<b>Filing Date:</b>	28-DEC-2015
<b>Time Stamp:</b>	14:20:45
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$240
RAM confirmation Number	012419INTEFSW14211300
Deposit Account	111410
Authorized User	Sandra Autry
<p>The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:</p> <p>37 CFR 1.16 (National application filing, search, and examination fees)</p> <p>37 CFR 1.17 (Patent application and reexamination processing fees)</p>	

Page 118 of 643

**Appx59478**

CX-1623

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant summary of interview with examiner	IntSum_MASCER002C2.pdf	20105	no	2
			31f061fe32c608341bc2ffbfa39bae99648f9443		
Warnings:					
Information:					
2		IDS_MASCER002C2.pdf	77510	yes	6
			70a27854034398d6edd68265392065df93833f3a		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Transmittal Letter		1	2	
	Information Disclosure Statement (IDS) Form (SB08)		3	6	
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	30329	no	2
			6da9416e274f85a477dfbe8cbbbe5ad553c6a32f		
Warnings:					
Information:					
Total Files Size (in bytes):			127944		



This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Docket No.: MASCER.002C2

January 23, 2019

Page 1 of 2

Please Direct All Correspondence to Customer Number 64735

---

**SUMMARY OF INTERVIEW**

Inventor	:	Jeroen Poeze
App. No	:	14/981290
Filed	:	December 28, 2015
For	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner	:	Liu, Chu Chuan
Art Unit	:	3735
Conf No.	:	9573

---

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Commissioner:

Pursuant to the Examiner Interview of January 22, 2019, Applicant submits this Summary of Interview for recording in the official file.

Attendees, Date and Type of Interview

A telephone interview was conducted on January 22, 2019, and attended by Examiner Chu Chuan Liu and Applicant's representative Scott Cromar.

Exhibits and/or Demonstrations

None.

Identification of Claims Discussed

Claims 12 and 14-19.

Identification of Cited/Disclosed Art Discussed

References of record.

**Application No.: 14/981290**  
**Filing Date: December 28, 2015**

Proposed Amendments

Certain proposed amendments to Claims 12 and 14-19 were discussed.

Substance and Results of Interview

It was agreed that certain amendments to the claims would place the application in condition for allowance. Applicant authorized the examiner to enter the amendments via an examiner's amendment. Applicant notes that the amendments were authorized to expedite allowance of the application, and not for patentability reasons, and Applicant reserves the right to pursue the previously pending claims in this or another (e.g., a continuing) application.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: January 23, 2019

By: /Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
Customer No. 64735  
(949) 760-0404

29799760

Docket No.: MAS CER.002C2

Customer No. 64735

---

**INFORMATION DISCLOSURE STATEMENT**

First Inventor :	Jeroen Poeze
App. No. :	14/981290
Filed :	December 28, 2015
For :	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner :	Liu, Chu Chuan
Art Unit :	3735
Conf. No. :	9573

---

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

**References and Listing**

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. Copies of any listed foreign and non-patent literature references are being submitted.

Pursuant to 37 CFR 1.97(g) and (h), Applicant makes no representation that the information is considered to be material to patentability. Additionally, inclusion on this list is not an admission that any of the cited documents are prior art in this application. Further, Applicant makes no representation regarding the completeness of this list, or that better art does not exist.

**No Disclaimers**

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

**Timing of Disclosure**

This Information Disclosure Statement is being filed after receipt of a First Office Action, but before the mailing date of a Final Action and before the mailing date of a Notice of Allowance.

This Statement is accompanied by the fees set forth in 37 CFR 1.17(p). The Commissioner is hereby authorized to charge any additional fees which may be required or to credit any overpayment to Account No. 11-1410.

Respectfully submitted,  
KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: January 23, 2019

By: /Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
Customer No. 64735  
(949) 760-0404

29805071

MASCER.002C2

PATENT

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

First Inventor	:	Jeroen Poeze
App. No.	:	14/981290
Filed	:	December 28, 2015
For	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner	:	Liu, Chu Chuan
Art Unit	:	3735
Conf. No.	:	9573

**RESPONSE TO OFFICE ACTION DATED JULY 10, 2018**

**Mail Stop Amendment**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Commissioner:

In response to the office action, please consider the following:

**Amendments to the Claims** are reflected in the listing of claims which begins on page 2 of this paper.

**Remarks** begin on page 4 of this paper.

Electronic Patent Application Fee Transmittal				
<b>Application Number:</b>		14981290		
<b>Filing Date:</b>		28-Dec-2015		
<b>Title of Invention:</b>		MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
<b>First Named Inventor/Applicant Name:</b>		Jeroen Poeze		
<b>Filer:</b>		Scott Cromar		
<b>Attorney Docket Number:</b>		MASCER.002C2		
Filed as Large Entity				
<b>Filing Fees for Utility under 35 USC 111(a)</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent-Appeals-and-Interference:</b>				
<b>Post-Allowance-and-Post-Issuance:</b>				
<b>Extension-of-Time:</b>				

CX-1623

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension - 1 month with \$0 paid	1251	1	200	200
<b>Miscellaneous:</b>				
<b>Total in USD (\$)</b>				<b>200</b>



CX-1623

<b>Electronic Acknowledgement Receipt</b>	
<b>EFS ID:</b>	34157317
<b>Application Number:</b>	14981290
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9573
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	64735
<b>Filer:</b>	Scott Cromar/Chelsea Veinot
<b>Filer Authorized By:</b>	Scott Cromar
<b>Attorney Docket Number:</b>	MASCER.002C2
<b>Receipt Date:</b>	30-OCT-2018
<b>Filing Date:</b>	28-DEC-2015
<b>Time Stamp:</b>	13:58:41
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$200
RAM confirmation Number	103118INTEFSW13592300
Deposit Account	111410
Authorized User	Chelsea Veinot
<p>The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:</p> <p>37 CFR 1.16 (National application filing, search, and examination fees)</p> <p>37 CFR 1.17 (Patent application and reexamination processing fees)</p>	

Page 128 of 643

**Appx59488**

CX-1623

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Response_MASCER002C2.pdf	49574	yes	8
			2273b788854660a9d733853e8ca8c0818c496f25		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Applicant Arguments/Remarks Made in an Amendment		4	8	
	Claims		2	3	
	Amendment/Req. Reconsideration-After Non-Final Reject		1	1	
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30640	no	2
			c88a21f23629cab2c4f73096d7759acd2f250576		
Warnings:					
Information:					
Total Files Size (in bytes):			80214		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

### REMARKS

Claims 12-19 were pending. By this response, Applicant has amended Claims 12-19, and canceled Claim 13, without prejudice or disclaimer of subject matter. Applicant reserves the right to pursue the previously pending claims and/or subject matter of the previously pending claims in this or a continuing application. Accordingly, Claims 12 and 14-19 are pending and presented for consideration.

#### Rejections under 35 U.S.C. § 112, first paragraph

Claims 13 and 15-19 were rejected under 35 U.S.C. § 112, first paragraph, as allegedly failing to comply with the written description requirement. Applicant respectfully traverses these rejections, the characterization of the pending claims, and each and every implicit and/or explicit reliance on Official Notice. However, in the interest of expediting allowance, and not for patentability reasons, Applicant has canceled Claim 13 and amended Claim 12 to include certain recitations similar to those of previously pending Claim 13. Applicant specifically reserves the right to pursue the subject matter of previously pending Claim 13 in this or a continuing application. Further, Applicant has amended Claims 15-19 to depend from Claim 14. Accordingly, Applicant requests withdrawal of the rejections of Claims 13 and 15-19 under 35 U.S.C. § 112, first paragraph.

#### Rejections under 35 U.S.C. § 112, second paragraph

Claims 13 and 15-19 were rejected under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite because the term “the single output signal” allegedly lacks antecedent basis. As noted above, Applicant has canceled Claim 13, rendering the rejection moot. Accordingly, Applicant requests withdrawal of the rejections of Claims 13 and 15-19 under 35 U.S.C. § 112, second paragraph.

#### Rejections under 35 U.S.C. § 112, fourth paragraph

Claims 14-19 were rejected under 35 U.S.C. § 112, fourth paragraph, as allegedly being of improper dependent form. Applicant respectfully traverses these rejections, the characterization of the pending claims, and each and every implicit and/or explicit potential

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

reliance on Official Notice. However, in the interest of expediting allowance, and not for patentability reasons, Applicant has amended Claims 12 and 14-19 as recited above. Applicant specifically reserves the right to pursue the subject matter of previously pending Claims 12 and 14-19 in this or a continuing application. Accordingly, Applicant requests withdrawal of the rejections of Claims 14-19 under 35 U.S.C. § 112, first paragraph.

*Rejections under 35 U.S.C. § 102*

Claims 12 and 14 were rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,360,113 to Dettling (“Dettling”). Applicant respectfully traverses each of these rejections, the characterization of the pending claims, and each and every implicit and/or explicit potential reliance on Official Notice. In view of the foregoing amendments and for at least the reasons set forth below, Applicant respectfully disagrees and requests reconsideration of the aforementioned claims.

Claims 12 and 14

Claim 12 has been amended as recited above. Claim 12 recited, in part (emphasis added):

A noninvasive physiological sensor comprising:  
 a front-end interface comprising:  
     one or more inputs configured to receive signals from respective  
     one or more detectors in the sensor;  
     **one or more transimpedance amplifiers for each respective  
     detector and configured to convert the signals from the respective one  
     or more detectors into output signals for each of the one or more  
     detectors; and**  
     **an averager, coupled to the one or more transimpedance  
     amplifiers, and configured to average the output signals from the  
     respective one or more transimpedance amplifiers into the single  
     output signal.**

At least these features of Claim 12 are not disclosed by Dettling. Accordingly, Applicant requests withdrawal of the rejection of Claims 12 under 35 U.S.C. § 102(b).

Applicant additionally requests the rejection under 35 U.S.C. § 102(b) of Claim 14, which depends directly from Claim 12, be withdrawn at least for reasons similar to those

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

discussed above with respect to Claim 12, and for the unique patentable features recited by Claim 14.

Rejections under 35 U.S.C. § 103

Claims 13 and 15 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Dettling, and further in view of U.S. Patent No. 4,653,498 to New, Jr. et al. (“New”). Applicant respectfully traverses each of these rejections, the characterization of the pending claims, and each and every implicit and/or explicit potential reliance on Official Notice. In view of the foregoing amendments and for at least the reasons set forth below, Applicant respectfully disagrees and requests reconsideration of the aforementioned claims.

Claim 13

As an initial matter, Applicant notes that Claim 13 has been canceled, rendering the rejection of Claim 13 moot. However, Applicant has amended Claim 12 to include certain recitations similar to those of previously pending Claim 13.

New fails to make up for the deficiencies of Dettling noted above in reference to Claim 12. For example, New discloses:

The information is updated from the microprocessor 16 on a continual and regular basis, modified only by a digital filter which serves the purpose of averaging recent pulse history with present information. This simply serves to smooth out transient small deviations in pulse rate and oxygen saturation due to physiologic and artifactual noise variations.

However, this disclosure of New does not disclose “one or more transimpedance amplifiers for each respective detector and configured to convert the signals from the respective one or more detectors into output signals for each of the one or more detectors; and an averager, coupled to the one or more transimpedance amplifiers, and configured to average the output signals from the respective one or more transimpedance amplifiers into the single output signal”, as recited by Claim 12

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

Accordingly, because none of Dettling, New, or a combination of the two, teaches or suggests each and every recitation of Claim 12, Applicant believes Claim 12 is patentable over the cited references.

Claim 15

Claim 15 has been amended as recited above. At least for reasons similar to those discussed above with respect to Claim 12, and for the unique patentable features recited by Claim 15, Applicant requests withdrawal of the rejection of Claim 15 under 35 U.S.C. § 103(a).

Request for Examiner Interview

In view of the foregoing, the present application is believed to be in condition for allowance, and such allowance is respectfully requested. If further issues remain to be resolved, the Applicant's undersigned attorney of record hereby formally requests a telephone interview with the Examiner. The Applicant's attorney can be reached at (949) 721-2812 or at the number listed below.

No Disclaimers or Disavowals

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child, or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

*Co-Pending Applications of Assignee*

Applicant wishes to draw the Examiner's attention to the following co-pending applications of the present application's assignee.

<b>Docket No.</b>	<b>Serial No.</b>	<b>Title</b>	<b>Filed</b>
MASCEP.006C2	15/660743	NOISE SHIELDING FOR A NONINVASIVE DEVICE	07/26/2017

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: October 30, 2018

By: /Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
Customer No. 64735  
(949) 760-0404

28870368



**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

### AMENDMENTS TO THE CLAIMS

1-11. (Previously Canceled)

12. (Currently Amended) A ~~front-end interface for a~~ noninvasive[[,]] physiological sensor,~~said front-end interface~~ comprising:

a front-end interface comprising:

one or more inputs configured to receive signals from respective one or more detectors in the sensor;

one or more transimpedance amplifiers for each respective detector and configured to convert the signals from the respective one or more detectors into [[an ]]output signals ~~having a stream~~ for each of the one or more detectors; and

~~an output configured to provide the output signal~~

an averager, coupled to the one or more transimpedance amplifiers, and configured to average the output signals from the respective one or more transimpedance amplifiers into the single output signal.

13. (Canceled)

14. (Currently Amended) The noninvasive physiological sensor ~~front-end interface~~ of Claim 12[[,]] further comprising:

a first detector ~~wherein at least a first of the one or more detectors, wherein the first detector in the sensor~~ comprises a set of photodiodes coupled together into a group.

15. (Currently Amended) The noninvasive physiological sensor ~~front-end interface~~ of Claim [[13]]14, wherein the ~~first detector in the sensor~~ comprises a set of photodiodes comprises two photodiodes coupled together.

16. (Currently Amended) The noninvasive physiological sensor ~~front-end interface~~ of Claim [[13]]14, wherein the ~~first detector in the sensor~~ comprises a set of photodiodes comprises three photodiodes coupled together.

17. (Currently Amended) The noninvasive physiological sensor ~~front-end interface~~ of Claim [[13]]14, wherein the ~~first detector in the sensor~~ comprises a set of photodiodes comprises four photodiodes coupled together.

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

18. **(Currently Amended)** The noninvasive physiological sensor front-end interface of Claim ~~[[13]]~~14, wherein the ~~first detector in the sensor comprises a set of photodiodes~~ comprises nine photodiodes coupled together.

19. **(Currently Amended)** The noninvasive physiological sensor front-end interface of Claim ~~[[13]]~~14, wherein the ~~first detector in the sensor comprises a set of~~ photodiodes coupled together ~~[[to ]]~~provide a detection area of approximately 1 mm<sup>2</sup>.

CX-1623

PTO/SB/06 (09-11)

Approved for use through 1/31/2014. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

<b>PATENT APPLICATION FEE DETERMINATION RECORD</b> Substitute for Form PTO-875				Application or Docket Number <b>14/981,290</b>		Filing Date <b>12/28/2015</b>		<input type="checkbox"/> To be Mailed		
ENTITY: <input checked="" type="checkbox"/> LARGE <input type="checkbox"/> SMALL <input type="checkbox"/> MICRO										
<b>APPLICATION AS FILED – PART I</b>										
		(Column 1)		(Column 2)						
FOR		NUMBER FILED		NUMBER EXTRA		RATE (\$)		FEE (\$)		
<input type="checkbox"/> BASIC FEE (37 CFR 1.16(a), (b), or (c))		N/A		N/A		N/A				
<input type="checkbox"/> SEARCH FEE (37 CFR 1.16(k), (i), or (m))		N/A		N/A		N/A				
<input type="checkbox"/> EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))		N/A		N/A		N/A				
TOTAL CLAIMS (37 CFR 1.16(i))		minus 20 =		*		X \$ =				
INDEPENDENT CLAIMS (37 CFR 1.16(h))		minus 3 =		*		X \$ =				
<input type="checkbox"/> APPLICATION SIZE FEE (37 CFR 1.16(s))		If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).								
<input type="checkbox"/> MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))										
* If the difference in column 1 is less than zero, enter "0" in column 2.						TOTAL				
<b>APPLICATION AS AMENDED – PART II</b>										
		(Column 1)		(Column 2)		(Column 3)				
AMENDMENT	<b>10/30/2018</b>		CLAIMS REMAINING AFTER AMENDMENT			HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))		* 7	Minus	** 20	= 0		X \$100 =	0	
	Independent (37 CFR 1.16(h))		* 1	Minus	***3	= 0		X \$460 =	0	
	<input type="checkbox"/> Application Size Fee (37 CFR 1.16(s))									
	<input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
	TOTAL ADD'L FEE								<b>0</b>	
		(Column 1)		(Column 2)		(Column 3)				
AMENDMENT			CLAIMS REMAINING AFTER AMENDMENT			HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))		*	Minus	**	=		X \$ =		
	Independent (37 CFR 1.16(h))		*	Minus	***	=		X \$ =		
	<input type="checkbox"/> Application Size Fee (37 CFR 1.16(s))									
	<input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
	TOTAL ADD'L FEE									
<p>* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.</p> <p>** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".</p> <p>*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".</p> <p>The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.</p> <p style="text-align: right;">LIE CHERYL CLARK</p>										

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

CX-1623



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/981,290	12/28/2015	Jeroen Poeze	MASCE002C2	9573

64735	7590	07/10/2018
KNOBBE, MARTENS, OLSON & BEAR, LLP		
MASIMO CORPORATION (MASIMO)		
2040 MAIN STREET		
FOURTEENTH FLOOR		
IRVINE, CA 92614		

EXAMINER	
LIU, CHU CHUAN	

ART UNIT	PAPER NUMBER
3735	

NOTIFICATION DATE	DELIVERY MODE
07/10/2018	ELECTRONIC

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jayna.cartee@knobbe.com  
 efiling@knobbe.com

CX-1623

<b>Office Action Summary</b>	<b>Application No.</b> 14/981,290	<b>Applicant(s)</b> POEZE ET AL.	
	<b>Examiner</b> CHU CHUAN (JJ) LIU	<b>Art Unit</b> 3735	<b>AIA (First Inventor to File) Status</b> No

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --**

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1) ☒ Responsive to communication(s) filed on 06/28/2018.  
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on \_\_\_\_.

2a) ☐ This action is **FINAL**.                      2b) ☒ This action is non-final.

3) ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on \_\_\_\_; the restriction requirement and election have been incorporated into this action.

4) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims\***

5) ☒ Claim(s) 12-19 is/are pending in the application.  
5a) Of the above claim(s) \_\_\_\_ is/are withdrawn from consideration.

6) ☐ Claim(s) \_\_\_\_ is/are allowed.

7) ☒ Claim(s) 12-19 is/are rejected.

8) ☐ Claim(s) \_\_\_\_ is/are objected to.

9) ☐ Claim(s) \_\_\_\_ are subject to restriction and/or election requirement.

\* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see [http://www.uspto.gov/patents/init\\_events/pph/index.jsp](http://www.uspto.gov/patents/init_events/pph/index.jsp) or send an inquiry to [PPHfeedback@uspto.gov](mailto:PPHfeedback@uspto.gov).

**Application Papers**

10) ☐ The specification is objected to by the Examiner.

11) ☒ The drawing(s) filed on 12/28/2015 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a) ☐ All    b) ☐ Some\*\*    c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\*\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b)  
Paper No(s)/Mail Date \_\_\_\_.

3) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date. \_\_\_\_.

4) ☐ Other: \_\_\_\_.

Application/Control Number: 14/981,290  
Art Unit: 3735

Page 2

#### **DETAILED ACTION**

1. The present application is being examined under the pre-AIA first to invent provisions.
2. Applicant's election without traverse of Group I, claims 2-4 and 12-19 and Species II, claims 12-19, in the reply filed on 06/28/2018 are acknowledged.
3. Claims 12-19 are pending for examination.
4. Claims 1-11 are cancelled.

#### ***Claim Rejections - 35 USC § 112***

5. The following is a quotation of the first paragraph of 35 U.S.C. 112(a):

(a) IN GENERAL.—The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor or joint inventor of carrying out the invention.

The following is a quotation of the first paragraph of pre-AIA 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

6. Claims 13 and 15-19 are rejected under 35 U.S.C. 112(a) or 35 U.S.C. 112 (pre-AIA), first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor or a joint inventor, or for pre-AIA the inventor(s), at the time the application was filed, had possession of the claimed invention. Claims that depend directly or indirectly from claim 13 is/are also rejected due to said dependency. Claim 13 recites "The front-end

Application/Control Number: 14/981,290

Page 3

Art Unit: 3735

interface of claim 12, further comprising an averager, coupled to the one or more transimpedance amplifiers and the output, configured to average digital output signals from the respective one or more transimpedance amplifiers into the single output signal". Paragraphs [0108]; [0293]; [0298]; [0300]; and [0303] of the PGPUB indicate generally "analog averaging" function of averaging circuit 1520 but no sufficient supports can be found for "average digital output signals from the respective one or more transimpedance amplifiers into the single output".

7. The following is a quotation of 35 U.S.C. 112(b):

(b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

8. Claim 13 and 15-19 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention. Claims that depend directly or indirectly from claim 13 is/are also rejected due to said dependency.

In regard to claim 13, "the single output signal" lacks of sufficient antecedent basis.

Application/Control Number: 14/981,290  
Art Unit: 3735

Page 4

9. The following is a quotation of 35 U.S.C. 112(d):

(d) REFERENCE IN DEPENDENT FORMS.—Subject to subsection (e), a claim in dependent form shall contain a reference to a claim previously set forth and then specify a further limitation of the subject matter claimed. A claim in dependent form shall be construed to incorporate by reference all the limitations of the claim to which it refers.

The following is a quotation of pre-AIA 35 U.S.C. 112, fourth paragraph:

Subject to the following paragraph [i.e., the fifth paragraph of pre-AIA 35 U.S.C. 112], a claim in dependent form shall contain a reference to a claim previously set forth and then specify a further limitation of the subject matter claimed. A claim in dependent form shall be construed to incorporate by reference all the limitations of the claim to which it refers.

10. Claims 14-19 are rejected under 35 U.S.C. 112(d) or pre-AIA 35 U.S.C. 112, 4th paragraph, as being of improper dependent form for failing to further limit the subject matter of the claim upon which it depends, or for failing to include all the limitations of the claim upon which it depends. In regard to claims 14-19, the limitations of the photodiodes, the number of photodiodes and the detection area are not further limit the subject matters recited in claims 12-13, wherein the detector is not positively recited (i.e. claims 12 and 13 only recite one or more inputs, one or more transimpedance amplifier(s), an output, and an averager. Applicant may cancel the claim(s), amend the claim(s) to place the claim(s) in proper dependent form, rewrite the claim(s) in independent form, or present a sufficient showing that the dependent claim(s) complies with the statutory requirements.

***Claim Rejections - 35 USC § 102***

11. The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –



Application/Control Number: 14/981,290

Page 5

Art Unit: 3735

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

12. Claims 12 and 14 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Dettling (USPN 6,360,113 – applicant cited). In regard to claim 12, Dettling discloses a front-end interface (elements 102, 102a, 102b, 102c and 114, Figs. 1A, 1B, 2, 3A-3B, and Fig. 4 and associated descriptions) for a noninvasive, physiological sensor (pulse oximeter, abstract; Col 3 line 58 – Col 4 lines 61), said front-end interface comprising: one or more inputs (inputs of elements 102, 102a, 102b, and 102c, Figs. 1A-1B, 2, 3A-3B, and Fig. 4 and associated descriptions) configured to receive signals from respective one or more detectors in the sensor (detector comprises DD1 and DD2, Figs. 1A, 1B, 2, 3A-3B, and Fig. 4 and associated descriptions); one or more transimpedance amplifiers for each respective detector (elements 201, 301, 303, and 401, Figs. 2, 3B and 4 and associated descriptions) and configured to convert the signals from the respective one or more detectors into an output signal having a stream for each of the one or more detectors (output signals from elements 201, 301, 303, and 401, Figs. 2, 3B and 4 and associated descriptions); and an output configured to provide the output signal (the output of element 102 to element 103, Figs. 1A-1B and associated descriptions; output(s) of elements 201, 301, 303, and 401, Figs. 2, 3B and 4 and associated descriptions; the output signals of elements 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, and/or 114, Figs. 1A-1B and associated descriptions, since the all the outputs comprise the output signal(s) of TIA(s)).

Application/Control Number: 14/981,290  
Art Unit: 3735

Page 6

In regard to claim 14, Dettling discloses at least a first of the one or more detectors in the sensor comprises a set of photodiodes coupled together into a group (detector comprises DD1 and DD2, Figs. 1A, 1B, 2, 3A-3B, and Fig. 4 and associated descriptions).

***Claim Rejections - 35 USC § 103***

13. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

14. Claims 13 and 15 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Dettling as applied to claims 12 and 14 above, and further in view of New, Jr. et al. (USPN 4,653,498). In regard to claim 13, Dettling discloses a processor (element 114, Figs. 1A and 1B and associated descriptions) coupled to the one or more transimpedance amplifiers (elements in 102, Figs. 1-4 and associated descriptions) and the output (the output signals of elements 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, and/or 114, Figs. 1A-1B and associated descriptions) comprises digital output signals from the respective one or more transimpedance amplifiers (outputs of element 113 comprises digital output signals from the respective one or more transimpedance amplifiers) but does not specifically disclose an averager configured to average digital output signals into *the single output signal*.

Application/Control Number: 14/981,290  
Art Unit: 3735

Page 7

New teaches an averager (digital filter, Col 11 lines 22-28) configured to average digital output signals from the respective one or more amplifiers into *the single output signal (rejected as best understood, see the 35 USC 112 2<sup>nd</sup> rejection above; amplifier 40, Fig. 2 and associated descriptions; averaging, Col 11 lines 22-28).*

It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the interface (Dettling) to incorporate the digital filter and associated function(s) as taught by New, since both devices are pulse oximeters and one ordinary would have recognized that the averaging function of the digital filter can smooth out transient small deviations in pulse rate and oxygen saturation due to physiologic and artifactual noise variations (see Col 11 lines 22-28 of New). The rationale would have been to obtain more accurate measurements.

In regard to claim 15, Dettling as modified by New discloses the first detector in the sensor comprises a set of two photodiodes coupled together (detector comprises DD1 and DD2, Figs. 1A, 1B, 2, 3A-3B, and Fig. 4 and associated descriptions of Dettling).

### ***Conclusion***

15. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. The BRI of claim 12 may only require one input to receive signals from a detector, one transimpedance amplifier to generate one output signal and an output to provide the output signal. Crowe et al. (USPGPUB 2009/0306487) teaches a PPG device comprises a photodiode (element 604, Fig. 6), a transimpedance amplifier

Application/Control Number: 14/981,290

Page 8

Art Unit: 3735

800 (element 605, Fig. 6 and element 800, Fig. 8; [0146-0147]) and an output to provide the output signal (output of elements 605, 606, 604, 608, and/or 609, Fig. 6). Wilcken et al. (USPGPUB 2006/0076473) teaches a 2-D detector array (Figs. 1-5 and associated descriptions) comprises multiple photodetector elements with one or more transimpedance amplifiers (Figs. 4-5). Wyles et al. (USPN 5,043,820 – applicant cited) teaches a detector array comprises transimpedance amplifiers for reach column of multiple detector elements of the array (Fig. 1a).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to CHU CHUAN (JJ) LIU whose telephone number is (571)270-5507. The examiner can normally be reached on M-TH 8:30am~5:00pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, JACQUELINE CHENG can be reached on (571)272-5596. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Application/Control Number: 14/981,290  
Art Unit: 3735

Page 9

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Eric Winakur/  
Primary Examiner, Art Unit 3735

/CHU CHUAN (JJ) LIU/  
Examiner, Art Unit 3735

<b>Notice of References Cited</b>	Application/Control No. 14/981,290	Applicant(s)/Patent Under Reexamination POEZE ET AL.	
	Examiner CHU CHUAN (JJ) LIU	Art Unit 3735	Page 1 of 1

**U.S. PATENT DOCUMENTS**

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-6,360,113 B1	03-2002	Dettling; Allen	A61B5/14551	600/322
*	B	US-4,653,498 A	03-1987	New, Jr.; William	A61B5/14551	600/324
*	C	US-2009/0306487 A1	12-2009	Crowe; John	A61B5/14551	600/322
*	D	US-2006/0076473 A1	04-2006	Wilcken; Stephen K.	H04B10/1121	250/214A
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				


**FOREIGN PATENT DOCUMENTS**

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

**NON-PATENT DOCUMENTS**


*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

\*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)  
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

<b><i>Index of Claims</i></b> 	<b>Application/Control No.</b> 14981290	<b>Applicant(s)/Patent Under Reexamination</b> POEZE ET AL.
	<b>Examiner</b> CHU CHUAN (JJ) LIU	<b>Art Unit</b> 3735

✓	<b>Rejected</b>	-	<b>Cancelled</b>	N	<b>Non-Elected</b>	A	<b>Appeal</b>
=	<b>Allowed</b>	÷	<b>Restricted</b>	I	<b>Interference</b>	O	<b>Objected</b>

<input type="checkbox"/> Claims renumbered in the same order as presented by applicant <input type="checkbox"/> CPA <input type="checkbox"/> T.D. <input type="checkbox"/> R.1.47										
CLAIM		DATE								
Final	Original	07/02/2018								
	1	-								
	2	-								
	3	-								
	4	-								
	5	-								
	6	-								
	7	-								
	8	-								
	9	-								
	10	-								
	11	-								
	12	✓								
	13	✓								
	14	✓								
	15	✓								
	16	✓								
	17	✓								
	18	✓								
	19	✓								

<b>Search Notes</b>  	<b>Application/Control No.</b>  14981290	<b>Applicant(s)/Patent Under Reexamination</b>  POEZE ET AL.
	<b>Examiner</b>  CHU CHUAN (JJ) LIU	<b>Art Unit</b>  3735

CPC- SEARCHED		
Symbol	Date	Examiner
A61B5/0205,1455,14551,14552,14532,72,7225	7/2/2018	CCL

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

\* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor Name Search (PALM and EAST)	7/2/2018	CCL
EAST Search (TEXT, USPGPUB, USPAT, CPC) See Search History	7/2/2018	CCL
Google NPL Search	7/2/2018	CCL

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

/CHU CHUAN (JJ) LIU/  
Examiner.Art Unit 3735



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 1 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	3,910,701	10/07/1975	Henderson et al.	
	2	4,114,604	09/19/1978	Shaw et al.	
	3	4,258,719	03/31/1981	Lewyn	
	4	4,267,844	05/19/1981	Yamanishi	
	5	4,444,471	04/24/1984	Ford et al.	
	6	4,655,225	04/07/1987	Dahne et al.	
	7	4,684,245	08/04/1987	Goldring	
	8	4,755,676	07/05/1988	Gaalema et al.	
	9	4,781,195	11/01/1988	Martin	
	10	4,805,623	02/21/1989	Jöbsis	
	11	4,880,304	11/14/1989	Jaeb et al.	
	12	4,960,128	10/02/1990	Gordon et al.	
	13	4,964,408	10/23/1990	Hink et al.	
	14	5,028,787	07/02/1991	Rosenthal, et al.	
	15	5,035,243	07/30/1991	Muz, Edwin	
	16	5,041,187	08/20/1991	Hink et al.	
	17	5,043,820	08/27/1991	Wyles et al.	
	18	5,069,213	12/03/1991	Polczynski	
	19	5,069,214	12/03/1991	Samaras et al.	
	20	5,077,476	12/31/1991	Rosenthal	
	21	5,086,229	02/04/1992	Rosenthal et al.	
	22	5,122,925	06/16/1992	Inpyn	
	23	5,131,391	07/21/1992	Sakai et al.	
	24	5,137,023	08/11/1992	Mendelson, et al.	
	25	5,159,929	11/03/1992	McMillen et al.	
	26	5,163,438	11/17/1992	Gordon et al.	
	27	5,222,295	06/29/1993	Dpriss Jr.	
	28	5,222,495	06/29/1993	Clarke et al.	
	29	5,222,496	06/29/1993	Clarke et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59512**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 2 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	5,249,576	10/05/1993	Goldberger et al.	
	31	5,278,627	01/11/1994	Aoyagi et al.	
	32	5,297,548	03/29/1994	Pologe, Jonas A.	
	33	5,319,355	06/07/1994	Russek	
	34	5,337,744	08/16/1994	Branigan	
	35	5,337,745	08/16/1994	Benaron	
	36	5,341,805	08/30/1994	Stavridi, et al.	
	37	5,362,966	11/08/1994	Rosenthal et al.	
	38	5,377,676	01/03/1995	Vari, et al.	
	39	5,427,093	06/27/1995	Ogawa et al.	
	40	5,431,170	07/11/1995	Mathews	
	41	5,437,275	08/01/1995	Amundsen et al.	
	42	5,441,054	08/15/1995	Tsuchiya	
	43	5,452,717	09/26/1995	Branigan et al.	
	44	5,456,252	10/10/1995	Vari, et al.	
	45	5,479,934	01/02/1996	Imran	
	46	5,482,034	01/09/1996	Lewis et al.	
	47	5,482,036	01/09/1996	Diab et al.	
	48	5,490,505	02/13/1996	Diab et al.	
	49	5,494,043	02/27/1996	O'Sullivan et al.	
	50	5,511,546	04/30/1996	Hon	
	51	5,533,511	07/09/1996	Kaspari et al.	
	52	5,534,851	07/09/1996	Russek	
	53	5,551,422	09/03/1996	Simonsen et al.	
	54	5,553,615	09/10/1996	Carim et al.	
	55	5,553,616	09/09/1996	Ham et al.	
	56	5,561,275	10/01/1996	Savage, et al.	
	57	5,562,002	10/08/1996	Lalin	
	58	5,590,649	01/07/1997	Caro et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59513**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 3 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	5,602,924	02/11/1997	Durand et al.	
	60	5,625,458	04/29/1997	Alfano et al.	
	61	5,632,272	05/27/1997	Diab et al.	
	62	5,638,816	06/17/1997	Kiani-Azarbayjany et al.	
	63	5,638,818	06/17/1997	Diab et al.	
	64	5,645,440	07/08/1997	Tobler et al.	
	65	5,676,143	10/14/1997	Simonsen, et al.	
	66	5,685,299	11/11/1997	Diab et al.	
	67	5,743,262	04/28/1998	Lepper, Jr. et al.	
	68	5,750,927	05/12/1998	Baltazar, Osni	
	69	5,752,914	05/19/1998	Delonzor et al.	
	70	5,758,644	06/02/1998	Diab et al.	
	71	5,760,910	06/02/1998	Lepper, Jr. et al.	
	72	5,766,131	06/16/1998	Kondo et al.	
	73	5,769,785	06/23/1998	Diab et al.	
	74	5,782,757	07/21/1998	Diab et al.	
	75	5,785,659	07/28/1998	Caro et al.	
	76	5,791,347	08/11/1998	Flaherty et al.	
	77	5,792,052	08/11/1998	Isaacson et al.	
	78	5,810,734	09/22/1998	Caro et al.	
	79	5,823,950	10/20/1998	Diab et al.	
	80	5,826,885	10/27/1998	Helgeland	
	81	5,830,131	11/03/1998	Caro et al.	
	82	5,833,618	11/10/1998	Caro et al.	
	83	5,851,178	12/22/1998	Aronow	
	84	5,860,919	01/19/1999	Kiani-Azarbayjany et al.	
	85	5,890,929	04/06/1999	Mills et al.	
	86	5,902,235	05/11/1999	Lewis et al.	
	87	5,903,357	05/11/1999	Colak	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59514**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 4 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	5,904,654	05/18/1999	Wohltmann et al.	
	89	5,919,134	07/06/1999	Diab	
	90	5,934,925	08/10/1999	Tobler et al.	
	91	5,940,182	08/17/1999	Lepper, Jr. et al.	
	92	5,957,840	09/28/1999	Terasawa et al.	
	93	5,995,855	11/30/1999	Kiani et al.	
	94	5,997,343	12/07/1999	Mills et al.	
	95	6,002,952	12/14/1999	Diab et al.	
	96	6,011,986	01/04/2000	Diab et al.	
	97	6,027,452	02/22/2000	Flaherty et al.	
	98	6,036,642	03/14/2000	Diab et al.	
	99	6,045,509	04/04/2000	Caro et al.	
	100	6,049,727	04/11/2000	Crothall, Katherine D.	
	101	6,067,462	05/23/2000	Diab et al.	
	102	6,081,735	06/27/2000	Diab et al.	
	103	6,088,607	07/11/2000	Diab et al.	
	104	6,110,522	08/29/2000	Lepper, Jr. et al.	
	105	6,124,597	09/26/2000	Shehada	
	106	6,128,521	10/03/2000	Marro et al.	
	107	6,129,675	10/10/2000	Jay	
	108	6,144,866	11/07/2000	Miesel et al.	
	109	6,144,868	11/07/2000	Parker	
	110	6,151,516	11/21/2000	Kiani-Azarbayjany et al.	
	111	6,152,754	11/28/2000	Gerhardt et al.	
	112	6,157,850	12/05/2000	Diab et al.	
	113	6,165,005	12/26/2000	Mills et al.	
	114	6,172,743	01/09/2001	Kley, et al.	
	115	6,181,958	01/30/2001	Steuer et al.	
	116	6,184,521	02/06/2001	Coffin, IV et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59515**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 5 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	117	6,206,830	03/27/2001	Diab et al.	
	118	6,223,063	04/24/2001	Chaiken et al.	
	119	6,229,856	05/08/2001	Diab et al.	
	120	6,232,609	05/15/2001	Snyder, et al.	
	121	6,236,872	05/22/2001	Diab et al.	
	122	6,241,683	06/05/2001	Macklem, et al.	
	123	6,253,097	06/26/2001	Aronow et al.	
	124	6,256,523	07/03/2001	Diab et al.	
	125	6,263,222	07/17/2001	Diab et al.	
	126	6,278,522	08/21/2001	Lepper, Jr. et al.	
	127	6,278,889	08/21/2001	Robinson	
	128	6,280,213	08/28/2001	Tobler et al.	
	129	6,285,896	09/04/2001	Tobler et al.	
	130	6,301,493	10/09/2001	Marro et al.	
	131	6,317,627	11/13/2001	Ennen et al.	
	132	6,321,100	11/20/2001	Parker	
	133	6,325,761	12/04/2001	Jay	
	134	6,334,065	12/25/2001	Al-Ali et al.	
	135	6,343,223	01/29/2002	Chin et al.	
	136	6,343,224	01/29/2002	Parker	
	137	6,345,194	02/05/2002	Robert Nelson, et al.	
	138	6,349,228	02/19/2002	Kiani et al.	
	139	6,353,750	03/05/2002	Kimura et al.	
	140	6,360,113	03/09/2002	Dettling, Allen	
	141	6,360,114	03/09/2002	Diab et al.	
	142	6,360,115	03/19/2002	Roger Greenwald, et al.	
	143	6,368,283	04/09/2002	Xu, et al.	
	144	6,371,921	04/16/2002	Caro et al.	
	145	6,377,829	04/23/2002	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59516**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 6 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	146	6,388,240	05/14/2002	Schulz et al.	
	147	6,397,091	05/28/2002	Diab et al.	
	148	6,430,437	08/06/2002	Marro	
	149	6,430,525	08/06/2002	Weber et al.	
	150	6,463,311	10/08/2002	Diab	
	151	6,470,199	10/22/2002	Kopotic et al.	
	152	6,501,975	12/31/2002	Diab et al.	
	153	6,505,059	01/07/2003	Kollias, et al.	
	154	6,515,273	02/04/2003	Al-Ali	
	155	6,519,487	02/11/2003	Parker	
	156	6,522,521	02/18/2003	Abdul-Hafiz et al.	
	157	6,525,386	02/25/2003	Mills et al.	
	158	6,526,300	02/25/2003	Kiani et al.	
	159	6,541,756	04/01/2003	Schulz et al.	
	160	6,542,764	04/01/2003	Al-Ali et al.	
	161	6,580,086	06/17/2003	Schulz et al.	
	162	6,584,336	06/24/2003	Ali et al.	
	163	6,595,316	07/22/2003	Cybulski et al.	
	164	6,597,932	07/22/2003	Tian et al.	
	165	6,597,933	07/22/2003	Kiani et al.	
	166	6,606,509	08/12/2003	Schmitt, Joseph M.	
	167	6,606,511	08/12/2003	Ali et al.	
	168	6,632,181	10/14/2003	Flaherty et al.	
	169	6,636,759	10/21/2003	Robinson	
	170	6,639,668	10/28/2003	Trepagnier, Pierre	
	171	6,639,867	10/28/2003	Shim	
	172	37,922	03/17/1983	Shim	
	173	6,640,116	10/28/2003	Diab	
	174	6,643,530	11/04/2003	Diab et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59517**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 7 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	175	6,650,917	11/18/2003	Diab et al.	
	176	6,654,624	11/25/2003	Diab et al.	
	177	6,658,276	12/02/2003	Diab et al.	
	178	6,661,161	12/09/2003	Lanzo et al.	
	179	6,668,185	12/23/2003	Toida	
	180	6,671,531	12/30/2003	Al-Ali et al.	
	181	6,678,543	01/13/2004	Diab et al.	
	182	6,681,133	01/20/2004	Chaiken et al.	
	183	6,684,090	01/27/2004	Ali et al.	
	184	6,684,091	01/27/2004	Parker	
	185	6,697,656	02/24/2004	Al-Ali	
	186	6,697,657	02/24/2004	Shehada, et al.	
	187	6,697,658	02/24/2004	Al-Ali	
	188	6,699,194	03/02/2004	Diab et al.	
	189	6,714,804	03/30/2004	Al-Ali et al.	
	190	6,721,582	04/13/2004	Trepagnier, et al.	
	191	6,721,585	04/13/2004	Parker	
	192	6,725,075	04/20/2004	Al-Ali	
	193	6,728,560	04/27/2004	Kollias, et al.	
	194	6,735,459	05/11/2004	Parker	
	195	6,745,060	06/01/2004	Diab et al.	
	196	6,748,254	06/08/2004	O'Neil et al.	
	197	6,760,607	07/06/2004	Al-Ali	
	198	6,770,028	08/03/2004	Ali et al.	
	199	6,771,994	08/03/2004	Kiani et al.	
	200	6,792,300	09/14/2004	Diab et al.	
	201	6,813,511	11/02/2004	Diab et al.	
	202	6,816,010	11/09/2004	Seetharaman et al.	
	203	6,816,241	11/09/2004	Grubisic, et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 8 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	204	6,816,741	11/09/2004	Diab	
	205	6,822,564	11/23/2004	Al-Ali	
	206	6,826,419	11/30/2004	Diab et al.	
	207	6,830,711	12/14/2004	Mills et al.	
	208	6,850,787	02/01/2005	Weber et al.	
	209	6,850,788	02/01/2005	Al-Ali	
	210	6,852,083	02/08/2005	Caro et al.	
	211	6,861,639	03/01/2005	Al-Ali	
	212	6,898,452	05/24/2005	Al-Ali et al.	
	213	6,912,413	06/28/2005	Rantala et al.	
	214	6,920,345	07/19/2005	Al-Ali et al.	
	215	6,931,268	08/16/2005	Kiani-Azarbayjany et al.	
	216	6,934,570	08/23/2005	Kiani et al.	
	217	6,939,305	09/06/2005	Flaherty et al.	
	218	6,943,348	09/13/2005	Coffin IV	
	219	6,950,687	09/27/2005	Al-Ali	
	220	6,961,598	11/01/2005	Diab	
	221	6,970,792	11/29/2005	Diab	
	222	6,979,812	12/27/2005	Al-Ali	
	223	6,985,764	01/10/2006	Mason et al.	
	224	6,993,371	01/31/2006	Kiani et al.	
	225	6,995,400	02/07/2006	Mizuyoshi	
	226	6,996,427	02/07/2006	Ali et al.	
	227	6,999,904	02/14/2006	Weber et al.	
	228	7,003,338	02/21/2006	Weber et al.	
	229	7,003,339	02/21/2006	Diab et al.	
	230	7,015,451	03/21/2006	Dalke et al.	
	231	7,024,233	04/04/2006	Ali et al.	
	232	7,027,849	04/11/2006	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59519**



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 9 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	233	7,030,749	04/18/2006	Al-Ali	
	234	7,039,449	05/02/2006	Al-Ali	
	235	7,041,060	05/09/2006	Flaherty et al	
	236	7,044,918	05/16/2006	Diab	
	237	7,047,054	05/16/2006	Benni	
	238	7,067,893	06/27/2006	Mills et al.	
	239	7,092,757	08/15/2006	Larson et al.	
	240	7,096,052	08/22/2006	Mason et al.	
	241	7,096,054	08/22/2006	Abdul-Hafiz et al.	
	242	7,132,641	11/07/2006	Schulz et al.	
	243	7,142,901	11/28/2006	Kiani et al.	
	244	7,149,561	12/12/2006	Diab	
	245	7,186,966	03/06/2007	Al-Ali	
	246	7,190,261	03/13/2007	Al-Ali	
	247	7,215,984	05/08/2007	Diab	
	248	7,215,986	05/08/2007	Diab	
	249	7,221,971	05/22/2007	Diab	
	250	7,225,006	05/29/2007	Al-Ali et al.	
	251	7,225,007	05/29/2007	Al-Ali	
	252	7,230,227	06/12/2007	Wilcken et al.	
	253	7,239,905	07/03/2007	Kiani-Azarbayjany et al.	
	254	7,245,953	07/17/2007	Parker	
	255	7,254,429	08/07/2007	Schurman et al.	
	256	7,254,431	08/07/2007	Al-Ali	
	257	7,254,433	08/07/2007	Diab et al.	
	258	7,254,434	08/07/2007	Schulz et al.	
	259	7,272,425	09/18/2007	Al-Ali	
	260	7,274,955	09/25/2007	Kiani et al.	
	261	7,280,858	10/09/2007	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59520**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 10 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	262	7,289,835	10/30/2007	Mansfield et al.	
	263	7,292,883	11/06/2007	De Felice et al.	
	264	7,295,866	11/13/2007	Al-Ali	
	265	7,328,053	02/05/2008	Diab et al.	
	266	7,332,784	02/19/2008	Mills, et al.	
	267	7,340,287	03/04/2008	Mason et al.	
	268	7,341,559	03/11/2008	Schulz et al.	
	269	7,343,186	03/11/2008	Lamego et al.	
	270	7,355,512	04/08/2008	Al-Ali	
	271	7,356,365	04/08/2008	Schurman	
	272	7,365,923	04/29/2008	Hargis et al.	
	273	7,371,981	05/13/2008	Abdul-Hafiz	
	274	7,373,193	05/13/2008	Al-Ali et al.	
	275	7,373,194	05/13/2008	Weber et al.	
	276	7,376,453	05/20/2008	Diab et al.	
	277	7,377,794	05/27/2008	Al Ali et al.	
	278	7,377,899	05/27/2008	Weber et al.	
	279	7,383,070	06/03/2008	Diab et al.	
	280	7,395,189	07/01/2008	Qing et al.	
	281	7,415,297	08/19/2008	Al-Ali et al.	
	282	7,428,432	09/23/2008	Ali et al.	
	283	7,438,683	10/21/2008	Al-Ali et al.	
	284	7,440,787	10/21/2008	Diab	
	285	7,454,240	11/18/2008	Diab et al.	
	286	7,467,002	12/16/2008	Weber et al.	
	287	7,469,157	12/23/2008	Diab et al.	
	288	7,471,969	12/30/2008	Diab et al.	
	289	7,471,971	12/30/2008	Diab et al.	
	290	7,483,729	01/27/2009	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59521**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 11 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	291	7,483,730	01/27/2009	Diab et al.	
	292	7,489,958	02/10/2009	Diab et al.	
	293	7,496,391	02/24/2009	Diab et al.	
	294	7,496,393	02/24/2009	Diab et al.	
	295	7,499,741	03/03/2009	Diab et al.	
	296	7,499,835	03/03/2009	Weber et al.	
	297	7,500,950	03/10/2009	Al-Ali et al.	
	298	7,509,153	03/24/2009	Blank et al.	
	299	7,509,154	03/24/2009	Diab et al.	
	300	7,509,494	03/24/2009	Al-Ali	
	301	7,510,849	03/31/2009	Schurman et al.	
	302	7,526,328	04/28/2009	Diab et al.	
	303	7,530,942	05/12/2009	Diab	
	304	7,530,949	05/12/2009	Al Ali et al.	
	305	7,530,955	05/12/2009	Diab et al.	
	306	7,563,110	07/21/2009	Al-Ali et al.	
	307	7,596,398	09/29/2009	Al-Ali et al.	
	308	7,606,606	10/20/2009	Laakkonen	
	309	7,618,375	11/17/2009	Flaherty	
	310	7,647,083	01/12/2010	Al-Ali et al.	
	311	7,657,294	02/02/2010	Eghbal et al.	
	312	7,657,295	02/02/2010	Coakley et al.	
	313	7,657,296	02/02/2010	Raridan et al.	
	314	7,729,733	06/01/2010	Al-Ali et al.	
	315	7,734,320	06/08/2010	Al-Ali	
	316	7,761,127	07/20/2010	Al-Ali et al.	
	317	7,761,128	07/20/2010	Al-Ali et al.	
	318	7,764,982	07/27/2010	Dalke et al.	
	319	7,791,155	09/07/2010	Diab	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59522**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 12 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	320	7,801,581	09/21/2010	Diab	
	321	7,809,418	10/05/2010	Xu	
	322	7,822,452	10/26/2010	Schurman et al.	
	323	7,844,313	11/30/2010	Kiani et al.	
	324	7,844,314	11/30/2010	Al-Ali	
	325	7,844,315	11/30/2010	Al-Ali	
	326	7,865,222	01/04/2011	Weber et al.	
	327	7,873,497	01/18/2011	Weber et al.	
	328	7,880,606	02/01/2011	Al-Ali	
	329	7,880,626	02/01/2011	Al-Ali et al.	
	330	7,891,355	02/22/2011	Al-Ali et al.	
	331	7,894,868	02/22/2011	Al-Ali et al.	
	332	7,899,506	03/01/2011	Xu et al.	
	333	7,899,507	03/01/2011	Al-Ali et al.	
	334	7,899,518	03/01/2011	Trepagnier et al.	
	335	7,904,132	03/08/2011	Weber et al.	
	336	7,909,772	03/22/2011	Popov et al.	
	337	7,910,875	03/22/2011	Al-Ali	
	338	7,919,713	04/05/2011	Al-Ali et al.	
	339	7,937,128	05/03/2011	Al-Ali	
	340	7,937,129	05/03/2011	Mason et al.	
	341	7,937,130	05/03/2011	Diab et al.	
	342	7,941,199	05/10/2011	Kiani	
	343	7,951,086	05/31/2011	Flaherty et al.	
	344	7,957,780	06/07/2011	Lamego et al.	
	345	7,962,188	06/14/2011	Kiani et al.	
	346	7,962,190	06/14/2011	Diab et al.	
	347	7,976,472	07/12/2011	Kiani	
	348	7,988,637	08/02/2011	Diab	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59523**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 13 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	349	7,990,382	08/02/2011	Kiani	
	350	7,991,446	08/02/2011	Al-Ali et al.	
	351	8,000,761	08/16/2011	Al-Ali	
	352	8,008,088	08/08/2011	Bellott et al.	
	353	8,019,400	09/13/2011	Diab et al.	
	354	8,028,701	10/04/2011	Al-Ali et al.	
	355	8,029,765	10/04/2011	Bellott et al.	
	356	8,036,728	10/11/2011	Diab et al.	
	357	8,044,998	10/25/2011	Heenan	
	358	8,046,040	10/25/2011	Ali et al.	
	359	8,046,041	10/25/2011	Diab et al.	
	360	8,046,042	10/25/2011	Diab et al.	
	361	8,048,040	11/01/2011	Kiani	
	362	8,050,728	11/01/2011	Al-Ali et al.	
	363	8,118,620	02/21/2012	Al-Ali et al.	
	364	8,126,528	02/28/2012	Diab et al.	
	365	8,126,531	02/28/2012	Crowley	
	366	8,128,572	03/06/2012	Diab et al.	
	367	8,130,105	03/06/2012	Al-Ali et al.	
	368	8,145,287	03/27/2012	Diab et al.	
	369	8,150,487	04/03/2012	Diab et al.	
	370	8,175,672	05/08/2012	Parker	
	371	8,180,420	05/15/2012	Diab et al.	
	372	8,182,443	05/22/2012	Kiani	
	373	8,185,180	05/22/2012	Diab et al.	
	374	8,190,223	05/29/2012	Al-Ali et al.	
	375	8,190,227	05/29/2012	Diab et al.	
	376	8,203,438	06/19/2012	Kiani et al.	
	377	8,203,704 (CERCA.004A)	06/19/2012	Merritt et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59524**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 14 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	378	8,219,170	07/10/2012	Hausmann et al.	
	379	8,224,411	07/17/2012	Al-Ali et al.	
	380	8,228,181	07/24/2012	Al-Ali	
	381	8,229,533	07/24/2012	Diab et al.	
	382	8,233,955	07/31/2012	Al-Ali et al.	
	383	8,244,325	08/14/2012	Al-Ali et al.	
	384	8,255,026	08/28/2012	Al-Ali	
	385	8,255,027	08/28/2012	Al-Ali et al.	
	386	8,255,028	08/28/2012	Al-Ali et al.	
	387	8,260,577	09/04/2012	Weber et al.	
	388	8,265,723	09/11/2012	McHale et al.	
	389	8,274,360	09/25/2012	Sampath et al.	
	390	8,301,217	10/30/2012	Al-Ali et al.	
	391	8,310,336	11/13/2012	Muhsin et al.	
	392	8,315,683	11/20/2012	Al-Ali et al.	
	393	8,332,006	12/11/2012	Naganuma et al.	
	394	8,337,403	12/25/2012	Al-Ali et al.	
	395	8,346,330	01/01/2013	Lamego	
	396	8,353,842	01/15/2013	Al-Ali et al.	
	397	8,355,766	01/15/2013	MacNeish, III et al.	
	398	8,359,080	01/22/2013	Diab et al.	
	399	8,364,223	01/29/2013	Al-Ali et al.	
	400	8,364,226	01/29/2013	Diab et al.	
	401	8,374,665	02/12/2013	Lamego	
	402	8,380,272	02/19/2013	Barrett et al.	
	403	8,385,995	02/26/2013	Al-ali et al.	
	404	8,385,996	02/26/2013	Smith et al.	
	405	8,388,353	03/05/2013	Kiani et al.	
	406	8,399,822	03/19/2013	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59525**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 15 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	407	8,401,602	03/19/2013	Kiani	
	408	8,405,608	03/26/2013	Al-Ali et al.	
	409	8,414,499	04/09/2013	Al-Ali et al.	
	410	8,418,524	04/16/2013	Al-Ali	
	411	8,421,022	04/16/2013	Rozenfeld	
	412	8,423,106	04/16/2013	Lamego et al.	
	413	8,428,674	04/23/2013	Duffy et al.	
	414	8,428,967	04/23/2013	Olsen et al.	
	415	8,430,817	04/30/2013	Al-Ali et al.	
	416	8,437,825 (CERCA.007A)	05/07/2013	Dalvi et al.	
	417	8,455,290	06/04/2013	Siskavich	
	418	8,457,703	06/04/2013	Al-Ali	
	419	8,457,707	06/04/2013	Kiani	
	420	8,463,349	06/11/2013	Diab et al.	
	421	8,466,286	06/18/2013	Bellot et al.	
	422	8,471,713	06/25/2013	Poeze et al.	
	423	8,473,020	06/25/2013	Kiani et al.	
	424	8,483,787	07/09/2013	Al-Ali et al.	
	425	8,489,364	07/16/2013	Weber et al.	
	426	8,498,684	07/30/2013	Weber et al.	
	427	8,509,867	08/13/2013	Workman et al.	
	428	8,515,509 (CERCA.005A)	08/20/2013	Bruinsma et al.	
	429	8,523,781	09/03/2013	Al-Ali	
	430	8,529,301	09/10/2013	Al-Ali et al.	
	431	8,532,727	09/10/2013	Ali et al.	
	432	8,532,728	09/10/2013	Diab et al.	
	433	8,547,209	10/01/2013	Kiani et al.	
	434	8,548,548	10/01/2013	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59526**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 16 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	435	8,548,550	10/01/2013	Al-Ali et al.	
	436	8,560,032	10/15/2013	Al-Ali et al.	
	437	8,560,034	10/15/2013	Diab et al.	
	438	8,570,503 (CERCA.004C1)	10/29/2013	Hung Vo	
	439	8,577,431 (CERCA.006A)	11/05/2013	Lamego et al.	
	440	8,584,345	10//2013	Al-Ali et al.	
	441	8,588,880	11//2013	Abdul-Hafiz et al.	
	442	8,600,467	12//2013	Al-Ali et al.	
	443	8,602,971	12/10/2013	Farr	
	444	8,606,342	12//2013	Diab	
	445	8,626,255	01//2014	Al-Ali et al.	
	446	8,630,691 (CERCA.003A)	01/14/2014	Lamego et al.	
	447	8,634,889	01//2014	Al-Ali et al.	
	448	8,641,631	02//2014	Sierra et al.	
	449	8,652,060	02//2014	Al-Ali	
	450	8,663,107	03//2014	Kiani	
	451	8,666,468	03//2014	Al-Ali	
	452	8,667,967	03//2014	Al-Ali et al.	
	453	8,670,811	03//2014	O'Reilly	
	454	8,670,814	03//2014	Diab et al.	
	455	8,676,286	03//2014	Weber et al.	
	456	8,682,407	03//2014	Al-Ali	
	457	8,688,183 (CERCA.008A)	04/01/2014	Bruinsma et al.	
	458	8,690,799	04//2014	Telfort et al.	
	459	8,700,112	04//2014	Kiani	
	460	8,702,627	04//2014	Telfort et al.	
	461	8,706,179	04//2014	Parker	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 17 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	462	8,712,494	04//2014	MacNeish, III et al.	
	463	8,715,206	05//2014	Telfort et al.	
	464	8,718,735	05//2014	Lamego et al.	
	465	8,718,737	05//2014	Diab et al.	
	466	8,720,249	05//2014	Al-Ali	
	467	8,721,541	05//2014	Al-Ali et al.	
	468	8,721,542	05//2014	Al-Ali et al.	
	469	8,723,677	05//2014	Kiani	
	470	8,740,792	06//2014	Kiani et al.	
	471	8,754,776	06//2014	Poeze et al.	
	472	8,755,535	06//2014	Telfort et al.	
	473	8,755,856	06//2014	Diab et al.	
	474	8,755,872	06//2014	Marinow	
	475	8,761,850	06//2014	Lamego	
	476	8,909,310 (CERCA.003D1)	12/09/2014	Lamego et al.	
	477	9,186,102 (MASCER.008C1)	11/17/2015	Bruinsma et al.	
	478	2002/0099279	07/25/2002	Pfeiffer et al.	
	479	2006/0005944	01/12/2006	Wang et al.	
	480	2006/0025659	02/02/2006	Kiguchi et al.	
	481	2007/0293792	12/20/2007	Sliwa et al.	
	482	2008/0130232	06/05/2008	Yamamoto	
	483	2008/0139908	06/12/2008	Kurth	
	484	2009/0030327	01/29/2009	Chance, Britton	
	485	2009/0043180	02/12/2009	Tschautscher et al.	
	486	2009/0129102	05/21/2009	Xiao et al.	
	487	2009/0259114	10/15/2009	Johnson et al.	
	488	2010/0004518 (011A)	01/07/2010	Vo et al.	
	489	2010/0030040 (CERCA.002A)	02/04/2010	Poeze et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59528**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 18 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	490	2011/0004082 (CERCA.002C1)	01/06/2011	Poeze et al.	
	491	2011/0105865	05/05/2011	Yu et al.	
	492	2013/0317370 (CERCA.007C1)	11/28/2013	Dalvi et al.	
	493	2014/0066783 (CERCA.006C1)	03/06/2014	Kiani et al.	
	494	2014/0296664 (CERCA.008C1)	03/27/2014	Bruinsma et al.	
	495	2014/0155712 (CERCA.003D1)	06/05/2014	Lamego et al.	
	496	D326,715	06/02/1992	Schmidt, Michael	
	497	D353,195	12/06/1994	Savage et al.	
	498	D353,196	12/06/1994	Savage et al.	
	499	D356,870	03/28/1995	Ivers et al.	
	500	D359,546	06/20/1995	Savage, et al.	
	501	D361,840	08/29/1995	Savage et al.	
	502	D362,063	09/05/1995	Savage et al.	
	503	D363,120	10/10/1995	Savage et al.	
	504	D378,414	03/11/1997	Allen et al.	
	505	D390,666	02/01/1998	Lagerlof, Ingemar	
	506	D393,830	04/28/1998	Tobler et al.	
	507	D403,070	12/22/1998	Maeda et al.	
	508	D414,870	10/05/1999	Saltzstein et al.	
	509	D452,012	12/11/2001	Phillips, Barney L.	
	510	D455,834	04/16/2002	Donars et al.	
	511	D463,561	09/24/2002	Fukatsu et al.	
	512	D481,459	10/28/2003	Nahm, Werner	
	513	D502,655	03/08/2005	Huang, Chun-Mu	
	514	D508,862	08/30/2005	Behar et al.	
	515	D510,625	10/11/2005	Widener et al.	
	516	D514,461	02/07/2006	Harju, Jonne	
	517	D535,031	01/09/2007	Barrett et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 19 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	518	D537,164	02/20/2007	Shigemori et al.	
	519	D547,454	07/24/2007	Hsieh, Chin-Chih	
	520	D549,830	08/28/2007	Behar et al.	
	521	D550,364	09/04/2007	Glover et al.	
	522	D551,350	09/18/2007	Lorimer et al.	
	523	D553,248	10/16/2007	Nguyen	
	524	D554,263	10/30/2007	Al-Ali	
	525	D562,985	02/26/2008	Brefka et al.	
	526	D566,282	04/08/2008	Al-Ali et al.	
	527	D567,125	04/22/2008	Okabe et al.	
	528	D569,001	05/13/2008	Omaki	
	529	D569,521	05/20/2008	Omaki	
	530	D587,657	03/03/2009	Al-Ali et al.	
	531	D603,966	11/10/2009	Jones et al.	
	532	D606,659 (010DA)	12/22/2009	Kiani et al.	
	533	D609,193	02/02/2010	Al-Ali et al.	
	534	D614,305	04/20/2010	Al-Ali et al.	
	535	D621,516 (009DA)	08/10/2010	Kiani et al.	
	536	D692,145	10/22/2013	Al-Ali et al.	
	537	RE38,476	03/01/2004	Diab et al.	
	538	RE38,492	04/06/2004	Diab et al.	
	539	RE39,672	06/05/2007	Shehada et al.	
	540	RE41,317	05/04/2010	Parker	
	541	RE41,912	11/02/2010	Parker	
	542	RE42,753	09/27/2011	Kiani-Azarbayjany et al.	
	543	RE43,169	02/07/2012	Parker	
	544	RE43,860	12/11/2012	Parker	
	545	RE44,823	04/2014	Parker	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59530**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
Examiner		Unknown
SHEET 20 OF 22		Attorney Docket No. MAS CER.002C2

## U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	546	RE44,875	04/2014	Kiani et al.	

## FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document Country Code-Number-Kind Code Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T <sup>1</sup>
	547	EP 419223	03/27/1991	Minnesota Mining and Manufacturing Company		
	548	JP 5756752 (MASCER.007JP)	06/05/2015	MASIMO LABORATORIES, INC.		
	549	JP 2002-500908 A	01/15/2002	Lightouch Medical Inc.		Abs
	550	JP 2007-389463 A	11/08/2007	Konica Minolta Sensing Inc.		Abs
	551	JP 2003-265444 A	09/24/2003	Shimadzu Corp.		Abs
	552	JP 06-327658 A /app JP 08-185864 /pub	07/16/1996	Matsushita Electric Ind Co Ltd		Abs
	553	JP 11-244266 /app JP 2001-66990 /pub	03/16/2001	Sumitomo Bakelite Co Ltd		Abs
	554	JP 04-158843 / app JP 05-325705 A / pub	12/10/1993	Fuji Porimatetsuku KK		Abs
	555	JP 2001-087250 A	04/03/2001	Cas Medical Systems Inc.		Abs
	556	JP 2006-177837 A	07/06/2006	Hitachi Ltd.		Abs
	557	JP 2003-024276 A	01/28/2003	Pentax Corp.		Abs
	558	JP 2008-099222 A	04/24/2008	Konica Minolta Holdings Inc.		Abs
	559	JP 2006-198321 A	08/03/2006	Hitachi Ltd.		Abs
	560	JP 2003-508104 A	03/04/2003	Quantum Vision Inc.		Abs
	561	WO 1993/12712	07/08/1993	Vivascan Corp		
	562	WO 1999/000053	01/07/1999	TOA Medical Electronics		
	563	WO 2000/25112	05/04/2000	Rolfe		
	564	WO 2014/149781 (CERCA.082WO)	09/25/2014	Cercacor Laboratories, Inc.		
	565	WO 2014/158820 (CERCA.067WO)	10/02/2014	Cercacor Laboratories, Inc.		
	566	WO 1999/01704	07/29/1999	General Electric Company		

## NON PATENT LITERATURE DOCUMENTS

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 21 OF 22	Attorney Docket No.	MASCER.002C2

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	567	PCT International Search Report, App. No. PCT/US2010/047899, Date of Actual Completion of Search: 01/26/2011, 4 pages.	
	568	International Search Report and Written Opinion for PCT/US2009/049638, mailed January 7, 2010.	
	569	International Search Report issued in Application No. PCT/US2009/052756, mailed February 10, 2009 in 14 pages.	
	570	International Preliminary Report on Patentability and Written Opinion of the International Searching Authority issued in Application No. PCT US2009/049638, mailed January 5, 2011 in 9 pages.	
	571	International Preliminary Report on Patentability and Written Opinion of the International Searching Authority issued in Application No. PCT/US2009/052756, mailed February 8, 2011 in 8 pages.	
	572	Burritt, Mary F.; Current Analytical Approaches to Measuring Blood Analytes; Vol. 36; No. 8(B); 1990	
	573	Hall, et al., Jeffrey W.; Near-Infrared Spectrophotometry: A New Dimension in Clinical Chemistry; Vol. 38; No. 9; 1992	
	574	Kuenstner, et al., J. Todd; Measurement of Hemoglobin in Unlysed Blood by Near-Infrared Spectroscopy; Vol. 48; Number 4, 1994	
	575	Manzke, et al., B., Multi Wavelength Pulse Oximetry in the Measurement of Hemoglobin Fractions; SPIE, Vol. 2676, April 24, 1996	
	576	Naumenko, E. K.; Choice of Wavelengths for Stable Determination of Concentrations of Hemoglobin Derivatives from Absorption Spectra of Erythrocytes; Vol. 63; No. 1; pp. 60-66 January – February 1996; Original article submitted November 3, 1994	
	577	Schmitt, Joseph M.; Simple Photon Diffusion Analysis of the Effects of Multiple Scattering on Pulse Oximetry; March 14, 1991; revised August 30, 1991	
	578	Schmitt, et al., Joseph M.; Measurement of Blood Hematocrit by Dual-Wavelength near-IR Photoplethysmography; Vol. 1641; 1992	
	579	Schnapp, et al., L.M.; Pulse Oximetry. Uses and Abuses.; Chest 1990; 98; 1244-1250 DOI 10.1378/Chest.98.5.1244	
	580	<a href="http://www.masimo.com/rainbow/pronto.htm">http://www.masimo.com/rainbow/pronto.htm</a> Noninvasive & Immediate Hemoglobin Testing, printed on August 20, 2009	
	581	<a href="http://www.masimo.com/pulseOximeter/Rad5.htm">http://www.masimo.com/pulseOximeter/Rad5.htm</a> ; Signal Extraction Pulse Oximeter, printed on August 20, 2009	
	582	<a href="http://blogderoliveira.blogspot.com/2008_02_01_archive.html">http://blogderoliveira.blogspot.com/2008_02_01_archive.html</a> ; Ricardo Oliveira, printed on August 20, 2009	
	583	<a href="http://www.masimo.com/rad-57/">http://www.masimo.com/rad-57/</a> ; Noninvasive Measurement of Methemoglobin, Carboxyhemoglobin and Oxyhemoglobin in the blood. Printed on August 20, 2009	
	584	<a href="http://amivital.ugr.es/blog/?tag=spo2">http://amivital.ugr.es/blog/?tag=spo2</a> ; Monitorizacion de la hemoglobina...y mucho mas, printed on August 20, 2009	
	585	<a href="http://www.masimo.com/spco/">http://www.masimo.com/spco/</a> ; Carboxyhemoglobin Noninvasive > Continuous > Immediate, printed on August 20, 2009	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L./

**Appx59532**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 22 OF 22	Attorney Docket No.	MASCER.002C2

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	586	http://www.masimo.com/PARTNERS/WELCHALLYN.htm; Welch Allyn Expands Patient Monitor Capabilities with Masimo Pulse Oximetry Technology, printed on August 20, 2009	
	587	http://www.masimo.com/pulseOximeter/PPO.htm; Masimo Personal Pulse Oximeter, printed on August 20, 2009	
	588	http://www.masimo.com/generalFloor/system.htm; Masimo Patient SafetyNet System at a Glance, printed on August 20, 2009	
	589	http://www.masimo.com/partners/GRASEBY.htm; Graseby Medical Limited, printed on August 20, 2009	
	590	Japanese Office Action, re JP Application No. 2011-516895, mailed September 2, 2014, with translation. (CERCA.007JP).	
	591	Japanese Notice of Allowance, re JP Application No. 2011-516895, issued on May 12, 2015, no translation. (CERCA/MASCER.007JP).	
	592	European Office Action issued in application no. 10763901.5 on 01/11/2013. (CERCA.008EP).	
	593	European Office Action issued in application no. 10763901.5 on 08/27/2014. (CERCA.008EP).	
	594	European Office Action issued in application no. 10763901.5 on 08/06/2015. (CERCA.008EP).	
	595	KANUKURTHY et al., "Data Acquisition Unit for an Implantable Multi-Channel Optical Glucose Sensor", Electro/Information Technology Conference, Chicago, IL, USA, May 17-20, 2007, pp. 1-6	
	596	SMITH, "The Pursuit of Noninvasive Glucose: 'Hunting the Deceitful Turkey'", 2006	
	597	SMALL et al., "Data Handling Issues for Near-Infrared Glucose Measurements", http://www.ieee.org/organizations/pubs/newsletters/leos/apr98/datahandling.htm, accessed 11/27/2007	

22330084

Examiner Signature	/CHU CHUAN LIU/	Date Considered	07/02/2018
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>			

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

Appx59533

**EAST Search History****EAST Search History (Prior Art)**

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	46	transimpedance with amplifier same averag\$3 and (600/310-344.ccls. A61B5/0205,1455,14551,14552,14532,72,7225.cpc.)	US- PGPUB; USPAT	OR	ON	2018/07/02 12:26
L2	484	transimpedance with amplifier same averag\$3	US- PGPUB; USPAT	OR	ON	2018/07/02 12:31
L3	147	transimpedance with amplifier same averag\$3 same digital	US- PGPUB; USPAT	OR	ON	2018/07/02 12:31
L4	3	averag\$3 with (digital "A/D") same (ppg spo2) and 600/310-344.ccls.	US- PGPUB; USPAT	OR	ON	2018/07/02 13:02
L5	185	averag\$3 with (digital "A/D") and 600/310-344.ccls.	US- PGPUB; USPAT	OR	ON	2018/07/02 13:04
L6	827	(Poeze near2 Jeroen Lamego near2 Marcelo Merritt near2 Sean Dalvi near2 Cristiano Vo near2 Hung Bruinsma near2 Johannes Lesmana near2 Ferdyan Kiani near3 Massi with Joe).in. MASIMO.as.	US- PGPUB; USPAT	OR	ON	2018/07/02 14:45
L7	89	6 and transimpedance with amplifier	US- PGPUB; USPAT	OR	ON	2018/07/02 14:45
L8	39	6 and transimpedance with amplifier same (detector photodiode)	US- PGPUB; USPAT	OR	ON	2018/07/02 14:47
L9	49	transimpedance with amplifier same averag\$3 and (600/310-344.ccls. A61B5/0205,1455,14551,14552,14532,14546,72,7225.cpc.)	US- PGPUB; USPAT	OR	ON	2018/07/02 14:49
L10	3	9 not 1	US- PGPUB; USPAT	OR	ON	2018/07/02 14:49
S1	1	"14981290"	US- PGPUB; USPAT	OR	ON	2018/04/24 07:30
S2	808	(Poeze near2 Jeroen Lamego near2 Marcelo Merritt near2 Sean Dalvi near2 Cristiano Vo near2 Hung Bruinsma near2 Johannes Lesmana near2 Ferdyan Kiani near3 Massi with Joe).in. MASIMO.as.	US- PGPUB; USPAT	OR	ON	2018/04/24 07:33
S3	85	S2 and front adj end with interface	US- PGPUB; USPAT	OR	ON	2018/04/24 07:33
S4	35	S3 and capacitor	US- PGPUB; USPAT	OR	ON	2018/04/24 07:34
S5	35	S4 and stream	US- PGPUB; USPAT	OR	ON	2018/04/24 07:34

EAST Search History

CX-1623

S6	3	"12829352"	US-PGPUB; USPAT	OR	ON	2018/04/24 07:35
S7	4	"12534827"	US-PGPUB; USPAT	OR	ON	2018/04/24 07:36
S8	51	("3910701"   "4114604"   "4258719"   "4267844"   "4444471"   "4655225"   "4684245"   "4755676"   "4781195"   "4805623"   "4880304"   "4960128"   "4964408"   "5028787"   "5035243"   "5041187"   "5043820"   "5069213"   "5069214"   "5077476"   "5086229"   "5122925"   "5131391"   "5137023"   "5159929"   "5163438"   "5222295"   "5222495"   "5222496"   "5249576"   "5278627"   "5297548"   "5319355"   "5337744"   "5337745"   "5341805"   "5362966"   "5377676"   "5427093"   "5431170"   "5437275"   "5441054"   "5452717"   "5456252"   "5479934"   "5482034"   "5482036"   "5490505"   "5494043"   "5511546"   "5533511").PN.	US-PGPUB; USPAT	OR	ON	2018/04/24 07:38
S9	145	switch\$3 with capacitor same digital and (600/310-344.ccls. A61B5/0205,0059,1455,14551,14552,14532,72.cpc.)	US-PGPUB; USPAT	OR	ON	2018/04/24 07:40
S10	598	("20020016536"   "20020039272"   "20020052547"   "20020091322"   "20020115918"   "20040039271"   "20040039272"   "20040049237"   "20040054269"   "20040054291"   "20050162761"   "20060005944"   "20060076473"   "20060167347"   "20060189859"   "20060208191"   "20060211924"   "20060220881"   "20060258922"   "20070149865"   "20070165218"   "20070197886"   "20070293792"   "20080036855"   "20080071154"   "20080130232"   "20080139908"   "20080208006"   "20090030327"   "20090043180"   "20090105565"   "20090129102"   "20090163775"   "20090259114"   "20100004518"   "20100030040"   "20100049018"   "20100090118"   "20110105865"   "20130317370"   "20140066783"   "20140155712"   "20140296664"   "4114604"   "4258719"   "4267844"   "4444471"   "4655225"   "4684245"   "4755676"   "4781195"   "4805623"   "4880304"   "4960128"   "4964408"   "5028787"   "5035243"   "5041187"   "5043820"   "5069213"   "5069214"   "5077476"   "5122925"   "5131391"   "5137023"   "5159929"   "5163438"   "5222495"   "5222496"   "5249576"   "5278627"   "5297548"   "5319355"   "5337744"   "5337745"   "5341805"   "5362966"   "5377676"   "5427093"   "5431170"   "5437275"   "5441054"   "5452717"   "5456252"   "5479934"   "5482034"   "5482036"   "5490505"   "5494043"   "5511546"   "5533511"   "5534851"   "5553615"   "5553616"   "5561275"   "5562002"   "5590649"   "5602924"   "5625458"   "5632272"   "5638816"   "5638818"   "5645440"   "5676143"   "5685299"   "5743262"   "5750927"   "5752914"   "5758644"   "5760910").PN. OR ("5769785"   "5782757"   "5785659"   "5791347"   "5792052"   "5810734"   "5823950"   "5826885"   "5830131"   "5833618"   "5860919"   "5890929"   "5902235"   "5903357"   "5904654"   "5919134"   "5934925"   "5940182"   "5995855"   "5997343"   "6002952"   "6011986"   "6027452"   "6036642"   "6045509"   "6049727"   "6067462"   "6081735"   "6088607"   "6110522"   "6124597"   "6128521"   "6129675"   "6144866"   "6144868"   "6151516"   "6152754"   "6157850"   "6165005"   "6172743"	US-PGPUB; USPAT; USOCR	OR	ON	2018/04/24 07:48



EAST Search History

CX-1623

"6181958"	"6184521"	"6206830"	"6223063"
"6229856"	"6232609"	"6236872"	"6241683"
"6253097"	"6256523"	"6263222"	"6278522"
"6278889"	"6280213"	"6285896"	"6301493"
"6317627"	"6321100"	"6325761"	"6334065"
"6343224"	"6345194"	"6349228"	"6353750"
"6360113"	"6360114"	"6360115"	"6368283"
"6371921"	"6377829"	"6388240"	"6397091"
"6430437"	"6430525"	"6463311"	"6470199"
"6501975"	"6505059"	"6515273"	"6519487"
"6522521"	"6525386"	"6526300"	"6541756"
"6542764"	"6580086"	"6584336"	"6595316"
"6597932"	"6597933"	"6606509"	"6606511"
"6632181"	"6636759"	"6639668"	"6639867"
"6640116"	"6643530"	"6650917"	"6654624"
"6658276"	"6661161"	"6668185"	"6671531"
"6678543"	"6681133"	"6684090"	"6684091"
"6697656"	"6697657"	"6697658"	"6699194"
"6714804"	"6721582"	"6721585"	"6725075"
"6728560"	"6735459"	"6745060"	"6760607"
"6770028"	"6771994"	"6792300"	"6813511"
"6816010"	PN. OR ("6816241"   "6816741"   "6822564"		
"6826419"	"6830711"	"6850787"	"6850788"
"6852083"	"6861639"	"6898452"	"6912413"
"6920345"	"6931268"	"6934570"	"6939305"
"6943348"	"6950687"	"6961598"	"6970792"
"6979812"	"6985764"	"6993371"	"6995400"
"6996427"	"6999904"	"7003338"	"7003339"
"7015451"	"7024233"	"7027849"	"7030749"
"7039449"	"7041060"	"7044918"	"7047054"
"7067893"	"7092757"	"7096052"	"7096054"
"7132641"	"7142901"	"7149561"	"7186966"
"7190261"	"7215984"	"7215986"	"7221971"
"7225006"	"7225007"	"7230227"	"7239905"
"7245953"	"7254429"	"7254431"	"7254433"
"7254434"	"7272425"	"7274955"	"7280858"
"7289835"	"7292883"	"7295866"	"7328053"
"7332784"	"7340287"	"7341559"	"7343186"
"7355512"	"7356365"	"7365923"	"7371981"
"7373193"	"7373194"	"7376453"	"7377794"
"7377899"	"7383070"	"7395189"	"7415297"
"7428432"	"7438683"	"7440787"	"7454240"
"7467002"	"7469157"	"7471969"	"7471971"
"7483729"	"7483730"	"7489958"	"7496391"
"7496393"	"7499741"	"7499835"	"7500950"
"7509153"	"7509154"	"7509494"	"7510849"
"7526328"	"7530942"	"7530949"	"7530955"
"7563110"	"7596398"	"7606606"	"7618375"
"7647083"	"7657294"	"7657295"	"7657296"
"7729733"	"7734320"	"7761127"	"7761128"
"7764982"	"7791155"	"7801581"	"7809418"
"7822452"	"7844313"	"7844314"	"7844315"
"7865222"	"7873497"	PN. OR ("7880606"   "7880626"	
"7891355"	"7894868"	"7899506"	"7899507"
"7899518"	"7904132"	"7909772"	"7910875"
"7919713"	"7937128"	"7937129"	"7937130"
"7941199"	"7951086"	"7957780"	"7962188"
"7962190"	"7976472"	"7988637"	"7990382"
"7991446"	"8000761"	"8008088"	"8019400"
"8028701"	"8029765"	"8036728"	"8044998"
"8046040"	"8046041"	"8046042"	"8048040"
"8050728"	"8118620"	"8126528"	"8126531"
"8128572"	"8130105"	"8145287"	"8150487"
"8175672"	"8180420"	"8182443"	"8185180"

EAST Search History

CX-1623

		"8190223"   "8190227"   "8203438"   "8203704"   "8219170"   "8224411"   "8228181"   "8229533"   "8233955"   "8244325"   "8255026"   "8255027"   "8255028"   "8260577"   "8265723"   "8274360"   "8301217"   "8310336"   "8315683"   "8332006"   "8337403"   "8346330"   "8353842"   "8355766"   "8359080"   "8364223"   "8364226"   "8374665"   "8380272"   "8385995"   "8385996"   "8388353"   "8399822"   "8401602"   "8405608"   "8414499"   "8418524"   "8421022"   "8423106"   "8428674"   "8428967"   "8430817"   "8437825"   "8455290"   "8457703"   "8457707"   "8463349"   "8466286"   "8471713"   "8473020"   "8483787"   "8489364"   "8498684"   "8509867"   "8515509"   "8523781"   "8529301"   "8532727"   "8532728"   "8547209"   "8548548"   "8548550"   "8560032"   "8560034"   "8570503"   "8577431"   "8584345"   "8588880"   "8600467"   "8602971"   "8606342"   "8626255"   "8630691"   "8634889"   "8641631"   "8652060"   "8663107"   "8666468"   "8667967").PN. OR ("8670811"   "8670814"   "8676286"   "8682407"   "8688183"   "8690799"   "8700112"   "8702627"   "8706179"   "8712494"   "8715206"   "8718735"   "8718737"   "8720249"   "8721541"   "8721542"   "8723677"   "8740792"   "8754776"   "8755535"   "8755856"   "8755872"   "8761850"   "8909310"   "D326715"   "D353195"   "D353196"   "D356870"   "D359546"   "D361840"   "D362063"   "D363120"   "D378414"   "D390666"   "D393830"   "D403070"   "D414870"   "D452012"   "D455834"   "D463561"   "D481459"   "D502655"   "D508862"   "D510625"   "D514461"   "D535031"   "D537164"   "D547454"   "D549830"   "D550364"   "D551350"   "D553248"   "D554263"   "D562985"   "D566282"   "D567125"   "D569001"   "D569521"   "D587657"   "D603966"   "D606659"   "D609193"   "D614305"   "D621516"   "D692145"   "RE38476"   "RE38492"   "RE39672"   "RE41317"   "RE41912"   "RE42753"   "RE43169"   "RE43860"   "RE44823"   "RE44875").PN. OR ("9277880").URPN.				
S11	76	S10 and capacitor	US- PGPUB; USPAT	OR	ON	2018/04/24 07:49
S12	25	S10 and capacitor same switch\$3	US- PGPUB; USPAT	OR	ON	2018/04/24 07:49
S13	0	simonson.in. and 600/310-344.ccls.	US- PGPUB; USPAT	OR	ON	2018/04/24 07:56
S14	23	simon\$4.in. and 600/310-344.ccls.	US- PGPUB; USPAT	OR	ON	2018/04/24 07:57
S15	569	transimpedance with amplifier and (600/310-344.ccls. A61B5/0205,1455,14551,14552,14532,72,7225.cpc.)	US- PGPUB; USPAT	OR	ON	2018/07/02 07:56
S16	169	S15 and transimpedance with (detector receiver photodiode)	US- PGPUB; USPAT	OR	ON	2018/07/02 07:56
S17	2	((("5676143") or ("20060076473")).PN.	US- PGPUB; USPAT	OR	OFF	2018/07/02 09:12
S18	1	("5043820").PN.	US-	OR	OFF	2018/07/02

EAST Search History

CX-1623

					PGPUB; USPAT			09:17
S19	1	("5490506").PN.			US- PGPUB; USPAT	OR	OFF	2018/07/02 09:25
S20	233	("20070149864"   "20070238955"   "20090247984"   "20090275844"   "20100217102"   "20110001605"   "20110082711"   "20110105854"   "20110208015"   "20110213212"   "20110230733"   "20110237911"   "20120059267"   "20120179006"   "20120209082"   "20120209084"   "20120227739"   "20120283524"   "20120296178"   "20120319816"   "20120330112"   "20130023775"   "20130041591"   "20130045685"   "20130046204"   "20130060147"   "20130096405"   "20130096936"   "20130190581"   "20130197328"   "20130211214"   "20130243021"   "20130253334"   "20130296672"   "20130324808"   "20130331670"   "20130338461"   "20140012100"   "20140034353"   "20140051953"   "20140058230"   "20140077956"   "20140081100"   "20140081175"   "20140094667"   "20140100434"   "20140114199"   "20140120564"   "20140121482"   "20140121483"   "20140127137"   "20140129702"   "20140135588"   "20140142401"   "20140163344"   "20140163402"   "20140166076"   "20140171763"   "20140180038"   "20140180154"   "20140194709"   "20140194711"   "20140194766"   "20140206963"   "20140213864"   "20140243627"   "20140266790"   "20140275808"   "20140275835"   "20140275871"   "20140275872"   "20140275881"   "20140288400"   "20140303520"   "20140316228"   "20140323825"   "20140330092"   "20140330098"   "20140330099"   "20140333440"   "20140336481"   "20140343436"   "20150018650"   "20150351697"   "20150351704"   "20150359429"   "20150366472"   "20150366507"   "20150374298"   "20150380875"   "20160000362"   "20160007930"   "20160029932"   "20160029933"   "20160045118"   "20160051205"   "20160058338"   "20160058347"   "20160066823"   "20160066824"   "20160066879"   "20160072429"   "20160073967"   "20160081552"   "20160095543"   "20160095548"   "20160103598"   "20160113527"   "20160143548"   "20160166183"   "20160166210"   "20160192869"   "20160196388"   "20160197436"   "20160213281"   "20180055390"   "4438338"   "4709413"   "5250342"   "5490506"   "8229532"   "8306596"   "8504128"   "8548549"   "8570167"   "8571617"   "8571618"   "8571619"   "8581732"   "8718738"   "8764671"   "8768423"   "8771204"   "8777634"   "8781543"   "8781544"   "8781549"   "8788003"   "8790268"   "8801613"   "8821397"   "8821415"   "8830449"   "8831700"   "8840549"   "8847740"   "8849365"   "8852094"   "8852994"   "8868147"   "8868150"   "8870792"   "8886271"   "8888539"   "8888708"   "8892180"   "8897847"   "8911377"   "8912909"   "8920317"   "8921699"   "8922382"   "8929964"   "8942777"   "8948834"   "8948835"   "8965471"   "8983564"   "8989831"   "8996085"   "8998809"   "9028429"   "9037207"   "9060721"   "9066666"   "9066680"   "9072474"   "9078560"   "9084569"   "9095316"   "9106038"   "9107625"   "9107626"   "9113831"   "9113832"   "9119595"   "9131881"   "9131882"   "9131883"   "9131917"   "9138180"   "9138182"   "9138192"   "9142117"   "9153112"   "9153121"   "9161696"   "9161713"			US- PGPUB; USPAT	OR	ON	2018/07/02 09:26

EAST Search History

CX-1623

		"9167995"   "9176141"   "9192312"   "9192329"   "9192351"   "9195385"   "9211072"   "9211095"   "9218454"   "9226696"   "9241662"   "9245668"   "9259185"   "9267572"   "9277880"   "9289167"   "9295421"   "9307928"   "9323894"   "9326712"   "9333316"   "9339220"   "9341565"   "9351673"   "9351675"   "9364181"   "9368671"   "9370325"   "9370326"   "9370335"   "9375185"   "9386953"   "9386961"   "9392945"   "9397448").PN.				
S21	55	("9591975"   "9668680"   "9717425"   "D755392"   "3910701"   "4114604"   "4258719"   "4267844"   "4444471"   "4655225"   "4684245"   "4755676"   "4781195"   "4805623"   "4880304"   "4960128"   "4964408"   "5028787"   "5035243"   "5041187"   "5043820"   "5069213"   "5069214"   "5077476"   "5086229"   "5122925"   "5131391"   "5137023"   "5159929"   "5163438"   "5222295"   "5222495"   "5222496"   "5249576"   "5278627"   "5297548"   "5319355"   "5337744"   "5337745"   "5341805"   "5362966"   "5377676"   "5427093"   "5431170"   "5437275"   "5441054"   "5452717"   "5456252"   "5479934"   "5482034"   "5482036"   "5490505"   "5494043"   "5511546"   "5533511").PN.	US- PGPUB; USPAT	OR	ON	2018/07/02 09:26
S22	5	(S20 S21) and transimpedance with (detector receiver photodiode)	US- PGPUB; USPAT	OR	ON	2018/07/02 09:26
S23	23	(S20 S21) and transimpedance	US- PGPUB; USPAT	OR	ON	2018/07/02 09:32
S24	18	S23 not S22	US- PGPUB; USPAT	OR	ON	2018/07/02 09:32
S25	0	al-ali.in. and array and transimpedance with (detector receiver photodiode)	US- PGPUB; USPAT	OR	ON	2018/07/02 09:46
S26	9	al-ali.in. and array and transimpedance	US- PGPUB; USPAT	OR	ON	2018/07/02 09:46
S27	161	al-ali.in. and array	US- PGPUB; USPAT	OR	ON	2018/07/02 09:47
S28	544	transimpedance with amplifier same photodiode same array	US- PGPUB; USPAT	OR	ON	2018/07/02 10:07
S29	12990	low adj pass adj filter with averag\$3	US- PGPUB; USPAT	OR	ON	2018/07/02 10:13
S30	130	S29 and 600/310-344.ccls.	US- PGPUB; USPAT	OR	ON	2018/07/02 10:13
S31	26	array with area same photodiode and 600/310-344.ccls.	US- PGPUB; USPAT	OR	ON	2018/07/02 10:20

7/2/2018 2:50:11 PM

C:\Users\cliu\Documents\EAST\Workspaces\14981290.wsp

EAST Search History

CX-1623

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 1 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	4,438,338	03-20-1984	Stitt	
	2	4,709,413	11-24-1987	Forrest	
	3	5,250,342	10-05-1993	Lang	
	4	5,490,506	02-13-1996	Takatani et al.	
	5	8,229,532	07-24-2012	Davis	
	6	8,306,596	11-06-2012	Schurman et al.	
	7	8,504,128	08-06-2013	Blank et al.	
	8	8,548,549	10-01-2013	Schurman et al.	
	9	8,570,167	10-29-2013	Al-Ali	
	10	8,571,617	10-29-2013	Reichgott et al.	
	11	8,571,618	10-29-2013	Lamego et al.	
	12	8,571,619	10-29-2013	Al-Ali et al.	
	13	8,581,732	11-12-2013	Al-Ali et al.	
	14	8,718,738	05-06-2014	Blank et al.	
	15	8,764,671	07-01-2014	Kiani	
	16	8,768,423	07-01-2014	Shakespeare et al.	
	17	8,771,204	07-08-2014	Telfort et al.	
	18	8,777,634	07-15-2014	Kiani et al.	
	19	8,781,543	07-15-2014	Diab et al.	
	20	8,781,544	07-15-2014	Al-Ali et al.	
	21	8,781,549	07-15-2014	Al-Ali et al.	
	22	8,788,003	07-22-2014	Schurman et al.	
	23	8,790,268	07-29-2014	Al-Ali	
	24	8,801,613	08-12-2014	Al-Ali et al.	
	25	8,821,397	09-02-2014	Al-Ali et al.	
	26	8,821,415	09-02-2014	Al-Ali et al.	
	27	8,830,449	09-09-2014	Lamego et al.	
	28	8,831,700	09-09-2014	Schurman et al.	
	29	8,840,549	09-23-2014	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

Appx59541

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 2 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	8,847,740	09-30-2014	Kiani et al.	
	31	8,849,365	09-30-2014	Smith et al.	
	32	8,852,094	10-07-2014	Al-Ali et al.	
	33	8,852,994	10-07-2014	Wojtczuk et al.	
	34	8,868,147	10-21-2014	Stippick et al.	
	35	8,868,150	10-21-2014	Al-Ali et al.	
	36	8,870,792	10-28-2014	Al-Ali et al.	
	37	8,886,271	11-11-2014	Kiani et al.	
	38	8,888,539	11-18-2014	Al-Ali et al.	
	39	8,888,708	11-18-2014	Diab et al.	
	40	8,892,180	11-18-2014	Weber et al.	
	41	8,897,847	11-25-2014	Al-Ali	
	42	8,911,377	12-16-2014	Al-Ali	
	43	8,912,909	12-16-2014	Al-Ali et al.	
	44	8,920,317	12-30-2014	Al-Ali et al.	
	45	8,921,699	12-30-2014	Al-Ali et al.	
	46	8,922,382	12-30-2014	Al-Ali et al.	
	47	8,929,964	01-06-2015	Al-Ali et al.	
	48	8,942,777	01-27-2015	Diab et al.	
	49	8,948,834	02-03-2015	Diab et al.	
	50	8,948,835	02-03-2015	Diab	
	51	8,965,471	02-24-2015	Lamego	
	52	8,983,564	03-17-2015	Al-Ali	
	53	8,989,831	03-24-2015	Al-Ali et al.	
	54	8,996,085	03-31-2015	Kiani et al.	
	55	8,998,809	04-07-2015	Kiani	
	56	9,028,429	05-12-2015	Telfort et al.	
	57	9,037,207	05-19-2015	Al-Ali et al.	
	58	9,060,721	06-23-2015	Reichgott et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

Appx59542

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 3 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	9,066,666	06-30-2015	Kiani	
	60	9,066,680	06-30-2015	Al-Ali et al.	
	61	9,072,474	07-07-2015	Al-Ali et al.	
	62	9,078,560	07-14-2015	Schurman et al.	
	63	9,084,569	07-21-2015	Weber et al.	
	64	9,095,316	08-04-2015	Welch et al.	
	65	9,106,038	08-11-2015	Telfort et al.	
	66	9,107,625	08-18-2015	Telfort et al.	
	67	9,107,626	08-18-2015	Al-Ali et al.	
	68	9,113,831	08-25-2015	Al-Ali	
	69	9,113,832	08-25-2015	Al-Ali	
	70	9,119,595	09-01-2015	Lamego	
	71	9,131,881	09-15-2015	Diab et al.	
	72	9,131,882	09-15-2015	Al-Ali et al.	
	73	9,131,883	09-15-2015	Al-Ali	
	74	9,131,917	09-15-2015	Telfort et al.	
	75	9,138,180	09-22-2015	Coverston et al.	
	76	9,138,182	09-22-2015	Al-Ali et al.	
	77	9,138,192	09-22-2015	Weber et al.	
	78	9,142,117	09-22-2015	Muhsin et al.	
	79	9,153,112	10-06-2015	Kiani et al.	
	80	9,153,121	10-06-2015	Kiani et al.	
	81	9,161,696	10-20-2015	Al-Ali et al.	
	82	9,161,713	10-20-2015	Al-Ali et al.	
	83	9,167,995	10-27-2015	Lamego et al.	
	84	9,176,141	11-03-2015	Al-Ali et al.	
	85	9,192,312	11-24-2015	Al-Ali	
	86	9,192,329	11-24-2015	Al-Ali	
	87	9,192,351	11-24-2015	Telfort et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

Appx59543



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 4 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	9,195,385	11-24-2015	Al-Ali et al.	
	89	9,211,072	12-15-2015	Kiani	
	90	9,211,095	12-15-2015	Al-Ali	
	91	9,218,454	12-22-2015	Kiani et al.	
	92	9,226,696	01-05-2016	Kiani	
	93	9,241,662	01-26-2016	Al-Ali et al.	
	94	9,245,668	01-26-2016	Vo et al.	
	95	9,259,185	02-16-2016	Abdul-Hafiz et al.	
	96	9,267,572	02-23-2016	Barker et al.	
	97	9,277,880	03-08-2016	Poeze et al.	
	98	9,289,167	03-22-2016	Diab et al.	
	99	9,295,421	03-29-2016	Kiani et al.	
	100	9,307,928	04-12-2016	Al-Ali et al.	
	101	9,323,894	04-26-2016	Kiani	
	102	9,326,712	05-03-2016	Kiani	
	103	9,333,316	05-10-2016	Kiani	
	104	9,339,220	05-17-2016	Lamego et al.	
	105	9,341,565	05-17-2016	Lamego et al.	
	106	9,351,673	05-31-2016	Diab et al.	
	107	9,351,675	05-31-2016	Al-Ali et al.	
	108	9,364,181	06-14-2016	Kiani et al.	
	109	9,368,671	06-14-2016	Wojtczuk et al.	
	110	9,370,325	06-21-2016	Al-Ali et al.	
	111	9,370,326	06-21-2016	McHale et al.	
	112	9,370,335	06-21-2016	Al-ali et al.	
	113	9,375,185	06-28-2016	Ali et al.	
	114	9,386,953	07-12-2016	Al-Ali	
	115	9,386,961	07-12-2016	Al-Ali et al.	
	116	9,392,945	07-19-2016	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59544**

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 5 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	117	9,397,448	07-19-2016	Al-Ali et al.	
	118	9,591,975	03-14-2017	Dalvi et al.	
	119	9,668,680	06-06-2017	Bruinsma et al.	
	120	9,717,425	08-01-2017	Kiani et al.	
	121	2007/0149864	06-28-2007	Laakkonen	
	122	2007/0238955	10-11-2007	Tearney et al.	
	123	2009/0247984	10-01-2009	Lamego et al.	
	124	2009/0275844	11-05-2009	Al-Ali	
	125	2010/0217102	08-26-2010	LeBoeuf et al.	
	126	2011/0001605	01-06-2011	Kiani et al.	
	127	2011/0082711	04-07-2011	Poeze et al.	
	128	2011/0105854	05-05-2011	Kiani et al.	
	129	2011/0208015	08-25-2011	Welch et al.	
	130	2011/0213212	09-01-2011	Al-Ali	
	131	2011/0230733	09-22-2011	Al-Ali	
	132	2011/0237911	09-29-2011	Lamego et al.	
	133	2012/0059267	03-08-2012	Lamego et al.	
	134	2012/0179006	07-12-2012	Jansen et al.	
	135	2012/0209082	08-16-2012	Al-Ali	
	136	2012/0209084	08-16-2012	Olsen et al.	
	137	2012/0227739	09-13-2012	Kiani	
	138	2012/0283524	11-08-2012	Kiani et al.	
	139	2012/0296178	11-22-2012	Lamego et al.	
	140	2012/0319816	12-20-2012	Al-Ali	
	141	2012/0330112	12-27-2012	Lamego et al.	
	142	2013/0023775	01-24-2013	Lamego et al.	
	143	2013/0041591	02-14-2013	Lamego	
	144	2013/0045685	02-21-2013	Kiani	
	145	2013/0046204	02-21-2013	Lamego et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

Appx59545

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 6 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	146	2013/0060147	03-07-2013	Welch et al.	
	147	2013/0096405	04-18-2013	Garfio	
	148	2013/0096936	04-18-2013	Sampath et al.	
	149	2013/0190581	07-25-2013	Al-Ali et al.	
	150	2013/0197328	08-01-2013	Diab et al.	
	151	2013/0211214	08-15-2013	Olsen	
	152	2013/0243021	09-19-2013	Siskavich	
	153	2013/0253334	09-26-2013	Al-Ali et al.	
	154	2013/0253334	09-26-2013	Al-Ali et al.	
	155	2013/0296672	11-07-2013	O'Neil et al.	
	156	2013/0324808	12-05-2013	Al-Ali et al.	
	157	2013/0331670	12-12-2013	Kiani	
	158	2013/0338461	12-19-2013	Lamego et al.	
	159	2014/0012100	01-09-2014	Al-Ali et al.	
	160	2014/0034353	02-06-2014	Al-Ali et al.	
	161	2014/0051953	02-20-2014	Lamego et al.	
	162	2014/0058230	02-27-2014	Abdul-Hafiz et al.	
	163	2014/0077956	03-20-2014	Sampath et al.	
	164	2014/0081100	03-20-2014	Muhsin et al.	
	165	2014/0081175	03-20-2014	Telfort	
	166	2014/0094667	04-03-2014	Schurman et al.	
	167	2014/0100434	04-10-2014	Diab et al.	
	168	2014/0114199	04-24-2014	Lamego et al.	
	169	2014/0120564	05-01-2014	Workman et al.	
	170	2014/0121482	05-01-2014	Merritt et al.	
	171	2014/0121483	05-01-2014	Kiani	
	172	2014/0127137	05-08-2014	Bellott et al.	
	173	2014/0129702	05-08-2014	Lamego et al.	
	174	2014/0135588	05-15-2014	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

Appx59546

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 7 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	175	2014/0142401	05-22-2014	Al-Ali et al.	
	176	2014/0163344	06-12-2014	Al-Ali	
	177	2014/0163402	06-12-2014	Lamego et al.	
	178	2014/0166076	06-19-2014	Kiani et al.	
	179	2014/0171763	06-19-2014	Diab	
	180	2014/0180038	06-26-2014	Kiani	
	181	2014/0180154	06-26-2014	Sierra et al.	
	182	2014/0194709	07-10-2014	Al-Ali et al.	
	183	2014/0194711	07-10-2014	Al-Ali	
	184	2014/0194766	07-10-2014	Al-Ali et al.	
	185	2014/0206963	07-24-2014	Al-Ali	
	186	2014/0213864	07-31-2014	Abdul-Hafiz et al.	
	187	2014/0243627	08-28-2014	Diab et al.	
	188	2014/0266790	09-18-2014	Al-Ali et al.	
	189	2014/0275808	09-18-2014	Poeze et al.	
	190	2014/0275835	09-18-2014	Lamego et al.	
	191	2014/0275871	09-18-2014	Lamego et al.	
	192	2014/0275872	09-18-2014	Merritt et al.	
	193	2014/0275881	09-18-2014	Lamego et al.	
	194	2014/0288400	09-25-2014	Diab et al.	
	195	2014/0303520	10-09-2014	Telfort et al.	
	196	2014/0316228	10-23-2014	Blank et al.	
	197	2014/0323825	10-30-2014	Al-Ali et al.	
	198	2014/0330092	11-06-2014	Al-Ali et al.	
	199	2014/0330098	11-06-2014	Merritt et al.	
	200	2014/0330099	11-06-2014	Al-Ali et al.	
	201	2014/0333440	11-13-2014	Kiani	
	202	2014/0336481	11-13-2014	Shakespeare et al.	
	203	2014/0343436	11-20-2014	Kiani	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

**Appx59547**

CX-1623

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 8 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	204	2015/0018650	01-15-2015	Al-Ali et al.	
	205	2015/0351697	12-10-2015	Weber et al.	
	206	2015/0359429	12-17-2015	Al-Ali et al.	
	207	2015/0351704	12-20-2015	Kiani et al.	
	208	2015/0366472	12-24-2015	Kiani	
	209	2015/0366507	12-24-2015	Blank	
	210	2015/0374298	12-31-2015	Al-Ali et al.	
	211	2015/0380875	12-31-2015	Coverston et al.	
	212	2016/0000362	01-07-2016	Diab et al.	
	213	2016/0007930	01-14-2016	Weber et al.	
	214	2016/0029932	02-04-2016	Al-Ali	
	215	2016/0029933	02-04-2016	Al-Ali et al.	
	216	2016/0045118	02-18-2016	Kiani	
	217	2016/0051205	02-25-2016	Al-Ali et al.	
	218	2016/0058338	03-03-2016	Schurman et al.	
	219	2016/0058347	03-03-2016	Reichgott et al.	
	220	2016/0066823	03-10-2016	Al-Ali et al.	
	221	2016/0066824	03-10-2016	Al-Ali et al.	
	222	2016/0066879	03-10-2016	Telfort et al.	
	223	2016/0072429	03-10-2016	Kiani et al.	
	224	2016/0073967	03-17-2016	Lamego et al.	
	225	2016/0081552	03-24-2016	Wojtczuk et al.	
	226	2016/0095543	04-07-2016	Telfort et al.	
	227	2016/0095548	04-07-2016	Al-Ali et al.	
	228	2016/0103598	04-14-2016	Al-Ali et al.	
	229	2016/0113527	04-28-2016	Al-Ali et al.	
	230	2016/0143548	05-26-2016	Al-Ali	
	231	2016/0166183	06-16-2016	Poeze et al.	
	232	2016/0166210	06-16-2016	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

Appx59548

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
SHEET 9 OF 9		Attorney Docket No. MASCER.002C2

## U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	<b>233</b>	2016/0192869	07-07-2016	Kiani et al.	
	<b>234</b>	2016/0196388	07-07-2016	Lamego	
	<b>235</b>	2016/0197436	07-07-2016	Barker et al.	
	<b>236</b>	2016/0213281	07-28-2016	Eckerbom, et al.	
	<b>237</b>	2018/0055390	03-01-2018	Kiani	
	<b>238</b>	D755,392	05-03-2016	Hwang et al.	

## FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document Country Code-Number-Kind Code Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T <sup>1</sup>
	<b>239</b>	EP 1 518 494	03-30-2005	Hitachi, Ltd.		
	<b>240</b>	WO 2001/09589	02-08-2001	Abbott Laboratories		
	<b>241</b>	WO 2010/003134	01-07-2010	Masimo Laboratories, Inc.		

## NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	<b>242</b>	European Office Action issued in Application No. 09791157.2, dated June 20, 2016. (MASCER.002EP).	

Examiner Signature	/CHU CHUAN LIU/	Date Considered	07/02/2018
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.			

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /C.L/

Appx59549

MASCER.002C2

PATENT

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

First Inventor	:	Jeroen Poeze
App. No.	:	14/981290
Filed	:	December 28, 2015
For	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner	:	Liu, Chu Chuan
Art Unit	:	3735
Conf. No.	:	9573

**RESPONSE TO OFFICE ACTION DATED MAY 2, 2018**

**Mail Stop Amendment**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Commissioner:

In response to the outstanding Office Action dated May 2, 2018 ("Office Action"), please consider the following:

**Amendments to the Claims** are reflected in the listing of claims which begins on page 2 of this paper.

**Remarks** begin on page 3 of this paper.

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

### AMENDMENTS TO THE CLAIMS

1-11. **(Canceled)**

12. **(Previously Presented)** A front-end interface for a noninvasive, physiological sensor, said front-end interface comprising:

one or more inputs configured to receive signals from respective one or more detectors in the sensor;

one or more transimpedance amplifiers for each respective detector and configured to convert the signals from the respective one or more detectors into an output signal having a stream for each of the one or more detectors; and

an output configured to provide the output signal.

13. **(Previously Presented)** The front-end interface of Claim 12, further comprising an averager, coupled to the one or more transimpedance amplifiers and the output, configured to average digital output signals from the respective one or more transimpedance amplifiers into the single output signal.

14. **(Previously Presented)** The front-end interface of Claim 12, wherein at least a first of the one or more detectors in the sensor comprises a set of photodiodes coupled together into a group.

15. **(Previously Presented)** The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set of two photodiodes coupled together.

16. **(Previously Presented)** The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set of three photodiodes coupled together.

17. **(Previously Presented)** The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set of four photodiodes coupled together.

18. **(Previously Presented)** The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set of nine photodiodes coupled together.

19. **(Previously Presented)** The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set photodiodes coupled together to provide a detection area of approximately 1 mm<sup>2</sup>.



**Application No.: 14/981290**  
**Filing Date: December 28, 2015**

### **REMARKS**

Claims 2-19 were pending. By this response Applicant has canceled Claims 2-11 without prejudice or disclaimer. Accordingly, Claims 12-19 are pending for consideration.

#### *Response to Restriction Requirement*

In response to the restriction requirement set forth in the Office Action, Applicant elects Group I (Claims 2-4 and 12-19) for prosecution in the present application. Applicant reserves the right to pursue the subject matter of the non-elected group in one or more divisional or continuation applications.

#### *Response to Election of Species Requirement*

With regard to the election of species requirement also included in the Office Action, Applicant hereby elects Species II (Figure 15I) for prosecution in the present application. Claims 12-19 read on the elected species, with at least Claim 12 being generic. Applicant believes features associated with Figure 15I and Claims 12-19 are also described in reference to various other figures and paragraphs of the application, including for example, Figure 1.

#### *No Disclaimers or Disavowals*

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child, or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,  
KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: June 28, 2018

By: /Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
Customer No. 64735  
(949) 760-0404

28406656

Docket No.: MAS CER.002C2

Customer No. 64735

---

**INFORMATION DISCLOSURE STATEMENT**

First Inventor :	Jeroen Poeze
App. No. :	14/981290
Filed :	December 28, 2015
For :	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner :	Liu, Chu Chuan
Art Unit :	3735
Conf. No. :	9573

---

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

**References and Listing**

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. Copies of any listed foreign and non-patent literature references are being submitted.

Pursuant to 37 CFR 1.97(g) and (h), Applicants make no representation that the information is considered to be material to patentability. Additionally, inclusion on this list is not an admission that any of the cited documents are prior art in this application. Further, Applicants make no representation regarding the completeness of this list, or that better art does not exist.

**No Disclaimers**

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

**Timing of Disclosure**

This Information Disclosure Statement is being filed before the receipt of a First Office Action on the merits, and presumably no fee is required. If a First Office Action on the merits

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

was mailed before the mailing date of this Statement, the Commissioner is authorized to charge the fee set forth in 37 CFR 1.17(p) to Deposit Account No. 11-1410.

Respectfully submitted,  
KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: June 28, 2018

By: /Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Registered Practitioner  
Customer No. 64735  
(949) 760-0404

28580302

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 1 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	4,438,338	03-20-1984	Stitt	
	2	4,709,413	11-24-1987	Forrest	
	3	5,250,342	10-05-1993	Lang	
	4	5,490,506	02-13-1996	Takatani et al.	
	5	8,229,532	07-24-2012	Davis	
	6	8,306,596	11-06-2012	Schurman et al.	
	7	8,504,128	08-06-2013	Blank et al.	
	8	8,548,549	10-01-2013	Schurman et al.	
	9	8,570,167	10-29-2013	Al-Ali	
	10	8,571,617	10-29-2013	Reichgott et al.	
	11	8,571,618	10-29-2013	Lamego et al.	
	12	8,571,619	10-29-2013	Al-Ali et al.	
	13	8,581,732	11-12-2013	Al-Ali et al.	
	14	8,718,738	05-06-2014	Blank et al.	
	15	8,764,671	07-01-2014	Kiani	
	16	8,768,423	07-01-2014	Shakespeare et al.	
	17	8,771,204	07-08-2014	Telfort et al.	
	18	8,777,634	07-15-2014	Kiani et al.	
	19	8,781,543	07-15-2014	Diab et al.	
	20	8,781,544	07-15-2014	Al-Ali et al.	
	21	8,781,549	07-15-2014	Al-Ali et al.	
	22	8,788,003	07-22-2014	Schurman et al.	
	23	8,790,268	07-29-2014	Al-Ali	
	24	8,801,613	08-12-2014	Al-Ali et al.	
	25	8,821,397	09-02-2014	Al-Ali et al.	
	26	8,821,415	09-02-2014	Al-Ali et al.	
	27	8,830,449	09-09-2014	Lamego et al.	
	28	8,831,700	09-09-2014	Schurman et al.	
	29	8,840,549	09-23-2014	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 2 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	8,847,740	09-30-2014	Kiani et al.	
	31	8,849,365	09-30-2014	Smith et al.	
	32	8,852,094	10-07-2014	Al-Ali et al.	
	33	8,852,994	10-07-2014	Wojtczuk et al.	
	34	8,868,147	10-21-2014	Stippick et al.	
	35	8,868,150	10-21-2014	Al-Ali et al.	
	36	8,870,792	10-28-2014	Al-Ali et al.	
	37	8,886,271	11-11-2014	Kiani et al.	
	38	8,888,539	11-18-2014	Al-Ali et al.	
	39	8,888,708	11-18-2014	Diab et al.	
	40	8,892,180	11-18-2014	Weber et al.	
	41	8,897,847	11-25-2014	Al-Ali	
	42	8,911,377	12-16-2014	Al-Ali	
	43	8,912,909	12-16-2014	Al-Ali et al.	
	44	8,920,317	12-30-2014	Al-Ali et al.	
	45	8,921,699	12-30-2014	Al-Ali et al.	
	46	8,922,382	12-30-2014	Al-Ali et al.	
	47	8,929,964	01-06-2015	Al-Ali et al.	
	48	8,942,777	01-27-2015	Diab et al.	
	49	8,948,834	02-03-2015	Diab et al.	
	50	8,948,835	02-03-2015	Diab	
	51	8,965,471	02-24-2015	Lamego	
	52	8,983,564	03-17-2015	Al-Ali	
	53	8,989,831	03-24-2015	Al-Ali et al.	
	54	8,996,085	03-31-2015	Kiani et al.	
	55	8,998,809	04-07-2015	Kiani	
	56	9,028,429	05-12-2015	Telfort et al.	
	57	9,037,207	05-19-2015	Al-Ali et al.	
	58	9,060,721	06-23-2015	Reichgott et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 3 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	9,066,666	06-30-2015	Kiani	
	60	9,066,680	06-30-2015	Al-Ali et al.	
	61	9,072,474	07-07-2015	Al-Ali et al.	
	62	9,078,560	07-14-2015	Schurman et al.	
	63	9,084,569	07-21-2015	Weber et al.	
	64	9,095,316	08-04-2015	Welch et al.	
	65	9,106,038	08-11-2015	Telfort et al.	
	66	9,107,625	08-18-2015	Telfort et al.	
	67	9,107,626	08-18-2015	Al-Ali et al.	
	68	9,113,831	08-25-2015	Al-Ali	
	69	9,113,832	08-25-2015	Al-Ali	
	70	9,119,595	09-01-2015	Lamego	
	71	9,131,881	09-15-2015	Diab et al.	
	72	9,131,882	09-15-2015	Al-Ali et al.	
	73	9,131,883	09-15-2015	Al-Ali	
	74	9,131,917	09-15-2015	Telfort et al.	
	75	9,138,180	09-22-2015	Coverston et al.	
	76	9,138,182	09-22-2015	Al-Ali et al.	
	77	9,138,192	09-22-2015	Weber et al.	
	78	9,142,117	09-22-2015	Muhsin et al.	
	79	9,153,112	10-06-2015	Kiani et al.	
	80	9,153,121	10-06-2015	Kiani et al.	
	81	9,161,696	10-20-2015	Al-Ali et al.	
	82	9,161,713	10-20-2015	Al-Ali et al.	
	83	9,167,995	10-27-2015	Lamego et al.	
	84	9,176,141	11-03-2015	Al-Ali et al.	
	85	9,192,312	11-24-2015	Al-Ali	
	86	9,192,329	11-24-2015	Al-Ali	
	87	9,192,351	11-24-2015	Telfort et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

CX-1623

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 4 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	9,195,385	11-24-2015	Al-Ali et al.	
	89	9,211,072	12-15-2015	Kiani	
	90	9,211,095	12-15-2015	Al-Ali	
	91	9,218,454	12-22-2015	Kiani et al.	
	92	9,226,696	01-05-2016	Kiani	
	93	9,241,662	01-26-2016	Al-Ali et al.	
	94	9,245,668	01-26-2016	Vo et al.	
	95	9,259,185	02-16-2016	Abdul-Hafiz et al.	
	96	9,267,572	02-23-2016	Barker et al.	
	97	9,277,880	03-08-2016	Poeze et al.	
	98	9,289,167	03-22-2016	Diab et al.	
	99	9,295,421	03-29-2016	Kiani et al.	
	100	9,307,928	04-12-2016	Al-Ali et al.	
	101	9,323,894	04-26-2016	Kiani	
	102	9,326,712	05-03-2016	Kiani	
	103	9,333,316	05-10-2016	Kiani	
	104	9,339,220	05-17-2016	Lamego et al.	
	105	9,341,565	05-17-2016	Lamego et al.	
	106	9,351,673	05-31-2016	Diab et al.	
	107	9,351,675	05-31-2016	Al-Ali et al.	
	108	9,364,181	06-14-2016	Kiani et al.	
	109	9,368,671	06-14-2016	Wojtczuk et al.	
	110	9,370,325	06-21-2016	Al-Ali et al.	
	111	9,370,326	06-21-2016	McHale et al.	
	112	9,370,335	06-21-2016	Al-ali et al.	
	113	9,375,185	06-28-2016	Ali et al.	
	114	9,386,953	07-12-2016	Al-Ali	
	115	9,386,961	07-12-2016	Al-Ali et al.	
	116	9,392,945	07-19-2016	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.



CX-1623

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
(Multiple sheets used when necessary)	Examiner	Liu, Chu Chuan
SHEET 5 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	117	9,397,448	07-19-2016	Al-Ali et al.	
	118	9,591,975	03-14-2017	Dalvi et al.	
	119	9,668,680	06-06-2017	Bruinsma et al.	
	120	9,717,425	08-01-2017	Kiani et al.	
	121	2007/0149864	06-28-2007	Laakkonen	
	122	2007/0238955	10-11-2007	Tearney et al.	
	123	2009/0247984	10-01-2009	Lamego et al.	
	124	2009/0275844	11-05-2009	Al-Ali	
	125	2010/0217102	08-26-2010	LeBoeuf et al.	
	126	2011/0001605	01-06-2011	Kiani et al.	
	127	2011/0082711	04-07-2011	Poeze et al.	
	128	2011/0105854	05-05-2011	Kiani et al.	
	129	2011/0208015	08-25-2011	Welch et al.	
	130	2011/0213212	09-01-2011	Al-Ali	
	131	2011/0230733	09-22-2011	Al-Ali	
	132	2011/0237911	09-29-2011	Lamego et al.	
	133	2012/0059267	03-08-2012	Lamego et al.	
	134	2012/0179006	07-12-2012	Jansen et al.	
	135	2012/0209082	08-16-2012	Al-Ali	
	136	2012/0209084	08-16-2012	Olsen et al.	
	137	2012/0227739	09-13-2012	Kiani	
	138	2012/0283524	11-08-2012	Kiani et al.	
	139	2012/0296178	11-22-2012	Lamego et al.	
	140	2012/0319816	12-20-2012	Al-Ali	
	141	2012/0330112	12-27-2012	Lamego et al.	
	142	2013/0023775	01-24-2013	Lamego et al.	
	143	2013/0041591	02-14-2013	Lamego	
	144	2013/0045685	02-21-2013	Kiani	
	145	2013/0046204	02-21-2013	Lamego et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 6 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	146	2013/0060147	03-07-2013	Welch et al.	
	147	2013/0096405	04-18-2013	Garfio	
	148	2013/0096936	04-18-2013	Sampath et al.	
	149	2013/0190581	07-25-2013	Al-Ali et al.	
	150	2013/0197328	08-01-2013	Diab et al.	
	151	2013/0211214	08-15-2013	Olsen	
	152	2013/0243021	09-19-2013	Siskavich	
	153	2013/0253334	09-26-2013	Al-Ali et al.	
	154	2013/0253334	09-26-2013	Al-Ali et al.	
	155	2013/0296672	11-07-2013	O'Neil et al.	
	156	2013/0324808	12-05-2013	Al-Ali et al.	
	157	2013/0331670	12-12-2013	Kiani	
	158	2013/0338461	12-19-2013	Lamego et al.	
	159	2014/0012100	01-09-2014	Al-Ali et al.	
	160	2014/0034353	02-06-2014	Al-Ali et al.	
	161	2014/0051953	02-20-2014	Lamego et al.	
	162	2014/0058230	02-27-2014	Abdul-Hafiz et al.	
	163	2014/0077956	03-20-2014	Sampath et al.	
	164	2014/0081100	03-20-2014	Muhsin et al.	
	165	2014/0081175	03-20-2014	Telfort	
	166	2014/0094667	04-03-2014	Schurman et al.	
	167	2014/0100434	04-10-2014	Diab et al.	
	168	2014/0114199	04-24-2014	Lamego et al.	
	169	2014/0120564	05-01-2014	Workman et al.	
	170	2014/0121482	05-01-2014	Merritt et al.	
	171	2014/0121483	05-01-2014	Kiani	
	172	2014/0127137	05-08-2014	Bellott et al.	
	173	2014/0129702	05-08-2014	Lamego et al.	
	174	2014/0135588	05-15-2014	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
(Multiple sheets used when necessary)	Examiner	Liu, Chu Chuan
SHEET 7 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	175	2014/0142401	05-22-2014	Al-Ali et al.	
	176	2014/0163344	06-12-2014	Al-Ali	
	177	2014/0163402	06-12-2014	Lamego et al.	
	178	2014/0166076	06-19-2014	Kiani et al.	
	179	2014/0171763	06-19-2014	Diab	
	180	2014/0180038	06-26-2014	Kiani	
	181	2014/0180154	06-26-2014	Sierra et al.	
	182	2014/0194709	07-10-2014	Al-Ali et al.	
	183	2014/0194711	07-10-2014	Al-Ali	
	184	2014/0194766	07-10-2014	Al-Ali et al.	
	185	2014/0206963	07-24-2014	Al-Ali	
	186	2014/0213864	07-31-2014	Abdul-Hafiz et al.	
	187	2014/0243627	08-28-2014	Diab et al.	
	188	2014/0266790	09-18-2014	Al-Ali et al.	
	189	2014/0275808	09-18-2014	Poeze et al.	
	190	2014/0275835	09-18-2014	Lamego et al.	
	191	2014/0275871	09-18-2014	Lamego et al.	
	192	2014/0275872	09-18-2014	Merritt et al.	
	193	2014/0275881	09-18-2014	Lamego et al.	
	194	2014/0288400	09-25-2014	Diab et al.	
	195	2014/0303520	10-09-2014	Telfort et al.	
	196	2014/0316228	10-23-2014	Blank et al.	
	197	2014/0323825	10-30-2014	Al-Ali et al.	
	198	2014/0330092	11-06-2014	Al-Ali et al.	
	199	2014/0330098	11-06-2014	Merritt et al.	
	200	2014/0330099	11-06-2014	Al-Ali et al.	
	201	2014/0333440	11-13-2014	Kiani	
	202	2014/0336481	11-13-2014	Shakespeare et al.	
	203	2014/0343436	11-20-2014	Kiani	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
	Examiner	Liu, Chu Chuan
SHEET 8 OF 9	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	204	2015/0018650	01-15-2015	Al-Ali et al.	
	205	2015/0351697	12-10-2015	Weber et al.	
	206	2015/0359429	12-17-2015	Al-Ali et al.	
	207	2015/0351704	12-20-2015	Kiani et al.	
	208	2015/0366472	12-24-2015	Kiani	
	209	2015/0366507	12-24-2015	Blank	
	210	2015/0374298	12-31-2015	Al-Ali et al.	
	211	2015/0380875	12-31-2015	Coverston et al.	
	212	2016/0000362	01-07-2016	Diab et al.	
	213	2016/0007930	01-14-2016	Weber et al.	
	214	2016/0029932	02-04-2016	Al-Ali	
	215	2016/0029933	02-04-2016	Al-Ali et al.	
	216	2016/0045118	02-18-2016	Kiani	
	217	2016/0051205	02-25-2016	Al-Ali et al.	
	218	2016/0058338	03-03-2016	Schurman et al.	
	219	2016/0058347	03-03-2016	Reichgott et al.	
	220	2016/0066823	03-10-2016	Al-Ali et al.	
	221	2016/0066824	03-10-2016	Al-Ali et al.	
	222	2016/0066879	03-10-2016	Telfort et al.	
	223	2016/0072429	03-10-2016	Kiani et al.	
	224	2016/0073967	03-17-2016	Lamego et al.	
	225	2016/0081552	03-24-2016	Wojtczuk et al.	
	226	2016/0095543	04-07-2016	Telfort et al.	
	227	2016/0095548	04-07-2016	Al-Ali et al.	
	228	2016/0103598	04-14-2016	Al-Ali et al.	
	229	2016/0113527	04-28-2016	Al-Ali et al.	
	230	2016/0143548	05-26-2016	Al-Ali	
	231	2016/0166183	06-16-2016	Poeze et al.	
	232	2016/0166210	06-16-2016	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	14/981290
	Filing Date	December 28, 2015
	First Named Inventor	Poeze, Jeroen et al.
	Art Unit	3735
(Multiple sheets used when necessary)	Examiner	Liu, Chu Chuan
SHEET 9 OF 9	Attorney Docket No.	MASCER.002C2

**U.S. PATENT DOCUMENTS**

Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	<b>233</b>	2016/0192869	07-07-2016	Kiani et al.	
	<b>234</b>	2016/0196388	07-07-2016	Lamego	
	<b>235</b>	2016/0197436	07-07-2016	Barker et al.	
	<b>236</b>	2016/0213281	07-28-2016	Eckerbom, et al.	
	<b>237</b>	2018/0055390	03-01-2018	Kiani	
	<b>238</b>	D755,392	05-03-2016	Hwang et al.	

**FOREIGN PATENT DOCUMENTS**

Examiner Initials	Cite No.	Foreign Patent Document Country Code-Number-Kind Code Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T <sup>1</sup>
	<b>239</b>	EP 1 518 494	03-30-2005	Hitachi, Ltd.		
	<b>240</b>	WO 2001/09589	02-08-2001	Abbott Laboratories		
	<b>241</b>	WO 2010/003134	01-07-2010	Masimo Laboratories, Inc.		

**NON PATENT LITERATURE DOCUMENTS**

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	<b>242</b>	European Office Action issued in Application No. 09791157.2, dated June 20, 2016. (MASCER.002EP).	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.



(11) **EP 1 518 494 A1**

(12) **EUROPEAN PATENT APPLICATION**

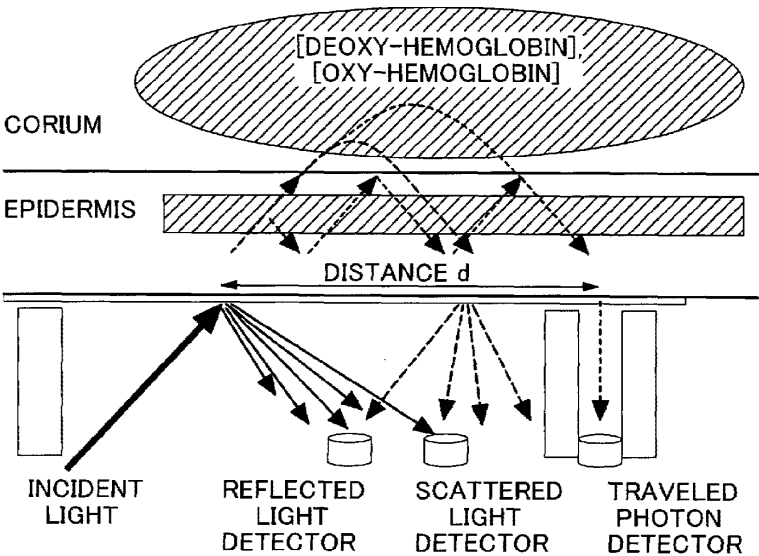
(43) Date of publication: 30.03.2005 Bulletin 2005/13  
(51) Int Cl.7: **A61B 5/00**, A61B 5/103, G01N 21/47  
(21) Application number: **04001845.9**  
(22) Date of filing: **28.01.2004**

<p>(84) Designated Contracting States: <b>AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR</b> Designated Extension States: <b>AL LT LV MK</b></p> <p>(30) Priority: <b>24.09.2003 JP 2003331857</b></p> <p>(71) Applicant: <b>Hitachi, Ltd.</b> <b>Chiyoda-ku, Tokyo 101-8010 (JP)</b></p>	<p>(72) Inventors: • <b>Cho, Ok-Kyung</b> <b>58239 Schwerte (DE)</b> • <b>Kim, Yoon-Ok</b> <b>58239 Schwerte (DE)</b></p> <p>(74) Representative: <b>Strehl Schübel-Hopf &amp; Partner</b> <b>Maximilianstrasse 54</b> <b>80538 München (DE)</b></p>
---	--

(54) **Optical measurement apparatus and blood sugar level measuring apparatus using the same**

(57) Blood sugar levels are measured non-invasively based on temperature measurement. Values of blood sugar levels non-invasively measured by a temperature measuring system are corrected using blood oxygen saturation and blood flow volume. Optical sensors (38,39,40) are provided for detecting scattered light, reflected light, and light that enters into the skin which travels out of the body surface. The measurement data is stabilized by taking into consideration the influence of the thickness of skin on blood oxygen saturation.

**FIG.1**



EP 1 518 494 A1

## EP 1 518 494 A1

**Description**

## BACKGROUND OF THE INVENTION

5 Field of the Invention

**[0001]** The present invention relates to non-invasive measurement of blood sugar levels for measuring glucose concentration in a living body without blood sampling, and an optical measurement apparatus suitable for that purpose.

10 Background Art

**[0002]** Hilson *et al.* report facial and sublingual temperature changes in diabetics following intravenous glucose injection (Non-Patent Document 1). Scott *et al.* discuss the issue of diabetics and thermoregulation (Non-Patent Document 2). Based on the knowledge gained from such researches, Cho *et al.* suggest a method and apparatus for determining blood glucose concentration by temperature measurement without requiring the collection of a blood sample (Patent Document 1 and 2).

**[0003]** Various other attempts have been made to determine glucose concentration without blood sampling. For example, a method has been suggested (Patent Document 3) whereby a measurement site is irradiated with near-infrared light of three wavelengths, and the intensity of traveled photon as well as the temperature of the living body is detected. A representative value of the second-order differentiated value of absorbance is then calculated, and the representative value is corrected in accordance with the difference of the living body temperature from a predetermined reference temperature. The blood sugar level corresponding to the thus corrected representative value is then determined. An apparatus is also provided (Patent Document 4) whereby a measurement site is heated or cooled while monitoring the living body temperature. The degree of attenuation of light based on light irradiation is measured at the moment of temperature change so that the glucose concentration responsible for the temperature-dependency of the degree of light attenuation can be measured. Further, an apparatus is reported (Patent Document 5) whereby an output ratio between reference light and the light transmitted by an irradiated sample is taken, and then the glucose concentration is calculated by a linear expression of the logarithm of the output ratio and the living body temperature. Another apparatus for measuring glucose concentration is provided (Patent Document No. 6) whereby the result of irradiating light from two light sources is detected by three infrared light detectors and also temperature is detected.

(Non-Patent Document 1) R.M. Hilson and T.D.R. Hockaday, "Facial and sublingual temperature changes following intravenous glucose injection in diabetics," *Diabete & Metabolisme*, 8, pp.15-19: 1982  
 (Non-Patent Document 2) A.R. Scott, T. Bennett, I.A. MacDonald, "Diabetes mellitus and thermoregulation," *Can. J. Physiol. Pharmacol.*, 65, pp. 1365-1376: 1987

(Patent Document 1) U.S. Patent No. 5,924,996  
 (Patent Document 2) U.S. Patent No. 5,795,305  
 (Patent Document 3) JP Patent Publication (Kokai) No. 2000-258343 A  
 (Patent Document 4) JP Patent Publication (Kokai) No. 10-33512 A (1998)  
 (Patent Document 5) JP Patent Publication (Kokai) No. 10-108857 A (1998)  
 (Patent Document 6) U.S. Patent No. 5,601,079

## SUMMARY OF THE INVENTION

**[0004]** Glucose (blood sugar) in blood is used for glucose oxidation reaction in cells to produce necessary energy for the maintenance of living bodies. In the basal metabolism state, in particular, most of the produced energy is converted into heat energy for the maintenance of body temperature. Thus, it can be expected that there is some relationship between blood glucose concentration and body temperature. However, as is evident from the way sicknesses cause fever, the body temperature also fluctuates due to factors other than blood glucose concentration. While methods have been proposed to determine blood glucose concentration by temperature measurement without blood sampling, they lack sufficient accuracy.

**[0005]** Further, while a method has been proposed that detects the result of irradiating light from two light sources using three infrared light detectors, and that also detects temperature for determining glucose concentration, the method, which only detects two kinds of optical intensity, is unable to provide sufficient accuracy.

**[0006]** It is the object of the invention to provide a method and apparatus for determining blood glucose concentration with high accuracy based on temperature data and optical data of the test subject without blood sampling.

**[0007]** Blood sugar is delivered to the cells throughout the human body via blood vessel systems, particularly the

## EP 1 518 494 A1

capillary blood vessels. In the human body, complex metabolic pathways exist. Glucose oxidation is a reaction in which, fundamentally, blood sugar reacts with oxygen to produce water, carbon dioxide, and energy. Oxygen herein refers to the oxygen delivered to the cells via blood. The volume of oxygen supply is determined by the blood hemoglobin concentration, the hemoglobin oxygen saturation, and the volume of blood flow. On the other hand, the heat produced

in the body by glucose oxidation is dissipated from the body by convection, heat radiation, conduction, and so on. On the assumption that the body temperature is determined by the balance between the amount of energy produced in the body by glucose burning, namely heat production, and heat dissipation such as mentioned above, the inventors set up the following model:

- (1) The amount of heat production and the amount of heat dissipation are considered equal.
- (2) The amount of heat production is a function of the blood glucose concentration and the volume of oxygen supply.
- (3) The volume of oxygen supply is determined by the blood hemoglobin concentration, the blood hemoglobin oxygen saturation, and the volume of blood flow in the capillary blood vessels.
- (4) The amount of heat dissipation is mainly determined by heat convection and heat radiation.

**[0008]** According to this model, we achieved the present invention after realizing that blood sugar levels can be accurately determined on the basis of the results of measuring the temperature of the body surface and measuring parameters relating to the blood oxygen concentration and the blood flow volume. The parameters can be measured, e.g., from a part of the human body, such as the fingertip. The parameters relating to convection and radiation can be determined by carrying out thermal measurements on the fingertip. The parameters relating to the blood hemoglobin concentration and the blood hemoglobin oxygen saturation can be determined by spectroscopically measuring blood hemoglobin and then finding the ratio between hemoglobin bound with oxygen and hemoglobin not bound with oxygen. The parameter relating to the volume of blood flow can be determined by measuring the amount of heat transfer from the skin.

**[0009]** The present invention provides, for example, an optical measurement apparatus comprising a first light source for producing light of a first wavelength, a second light source for producing light of a second wavelength, a first photodetector, a second photodetector and a third photodetector. The first and second light sources emit light in a time-divided manner such that a light incident point on the surface of an examined subject is irradiated with the light of the first wavelength and the light of the second wavelength in a time-divided manner. Mainly reflected light of the light of the first wavelength is incident on the first photodetector from the light incident point when the first light source is emitting, while mainly scattered light of the light of the second wavelength is incident thereon when the second light source is emitting. Mainly reflected light of the light of the second wavelength is incident on the second photodetector from the light incident point when the second light source is emitting, while mainly scattered light of the light of the first wavelength is incident thereon when the first light source is emitting. The third photodetector is adapted to receive light that leaves out of a region on the surface of the subject which is away from said light incident point.

**[0010]** In another example, the optical measurement apparatus comprises a first light source for producing light of a first wavelength that is irradiated onto a light incident point on the surface of an examined subject, a second light source for producing light of a second wavelength that is irradiated onto the light incident point on the surface of the subject from a direction different from that of the light of the first wavelength, a first photodetector on which reflected light of the light of the first wavelength reflected by the light incident point and scattered light of the light of the second wavelength are incident, a second photodetector for receiving reflected light of the light of the second wavelength reflected by the light incident point and scattered light of the light of the first wavelength, and a third detector for receiving light leaving out of a region on the surface of said subject that is away from said light incident point.

**[0011]** Preferably, the plane of incidence of the light of the first wavelength on the light incident point on the subject surface is substantially perpendicular to the plane of incidence of the light of the second wavelength. The plane of incidence herein refers to a plane that includes the incident ray and a normal at the incident point on the subject surface. Further, in the present specification, the ray that enters the incident plane after having been irradiated onto the incident point on the subject surface will be referred to as reflected light. The light that leaves in directions other than that of the incident plane from near the incident point will be referred to as scattered light. The scattered light that leaves out of a position on the subject surface that is away from the incident point will be referred to as traveled photon.

**[0012]** Preferably, the outgoing light from each light source is irradiated onto the light incident point on the subject surface via an optical fiber, and the reflected light, scattered light and traveled photon from the examined subject are incident on each photodetector via an optical fiber. An outgoing end of the light-irradiating optical fiber and an incident end of the optical fiber for detecting reflected or scattered light are preferably disposed near the plane of a cone whose apex corresponds to the light incident point on the subject surface. The first wavelength may be a wavelength at which the molar absorption coefficient of oxyhemoglobin is equal to that of deoxyhemoglobin, and the second wavelength may be a wavelength for detecting the difference in absorbance between the oxyhemoglobin and deoxyhemoglobin.

**[0013]** In another example, the invention provides a blood sugar level measuring apparatus including (1) a heat



## EP 1 518 494 A1

amount measuring portion for measuring a plurality of temperatures derived from the body surface. The resultant information is used for calculating the amount of convective heat transfer and the amount of radiation heat transfer constituting the dissipation of heat from the body surface. The apparatus also includes (2) a blood flow volume measuring portion for obtaining information concerning the volume of blood flow. It also includes (3) an optical measuring  
 5 portion for obtaining the hemoglobin concentration and hemoglobin oxygen saturation in blood. This portion includes a light source for generating light of at least two different wavelengths, an optical system for irradiating the body surface with light emitted by the light source, and at least three different photodetectors for detecting the light resulted by the light that has been shone on the body surface. The apparatus further includes (4) a storage portion for storing the relationships between individual parameters corresponding to the multiple temperatures, blood flow volume, hemo-  
 10 globin concentration and hemoglobin oxygen saturation in blood, and blood sugar levels. It also includes (5) a computing portion for converting the measurement values provided by the heat amount measuring portion, the blood flow volume measuring portion, and the optical measuring portion into the aforementioned parameters. The computing portion also computes a blood sugar level by applying the parameters to the relationships stored in the storage portion. The apparatus further includes (6) a display portion for displaying the blood sugar level computed by the computing portion. The appa-  
 15 optical measuring portion includes a first light source producing light of a first wavelength, a second light source producing light of a second wavelength, a first photodetector, a second photodetector, and a third photodetector. The first and second light sources alternately emit light such that a light incident point on the surface of the examined subject is irradiated with the light of the first and second wavelengths alternately. On the first photodetector is incident mainly reflected light of the first-wavelength light from the light incident point on the surface of the subject when the first light  
 20 source is emitting, while scattered light of the second-wavelength light is mainly incident thereon when the second light source is emitting. On the second photodetector is incident mainly reflected light of the second-wavelength light from the light incident point on the subject surface when the second light source is emitting, while scattered light of the first-wavelength light is mainly incident thereon when the first light source is emitting. The third photodetector receives light traveling out from a region distanced away from the light incident point on the subject surface.  
 25 **[0014]** In accordance with the invention, blood sugar levels can be determined non-invasively with accuracy similar to that according to the invasive methods according to the prior art.

## BRIEF DESCRIPTION OF THE DRAWINGS

30 **[0015]**

Fig. 1 shows a model of the transmission of light in the case of irradiating the skin surface with continuous light.  
 Fig. 2 shows a model of heat transfer from the body surface to a block.  
 Fig. 3 plots the measurement values of temperatures  $T_1$  and  $T_2$  as they change with time.  
 35 Fig. 4 shows an example of measuring the chronological change in temperature  $T_3$ .  
 Fig. 5 shows the relationships between measurement values provided by various sensors and the parameters derived therefrom.  
 Fig. 6 shows an upper plan view of a non-invasive blood sugar level measuring apparatus according to the present invention.  
 40 Fig. 7 shows the operating procedure for the apparatus.  
 Fig. 8 shows the measuring portion in detail.  
 Fig. 9 shows a block diagram of an example of the circuit for causing light-emitting diodes to emit light in a time-divided manner.  
 Fig. 10 shows in detail a measuring portion having spectroscopes.  
 45 Fig. 11 shows an optical sensor portion and the measuring portion in detail.  
 Fig. 12 shows in detail the measuring portion for a plurality of wavelengths.  
 Fig. 13 shows a conceptual chart illustrating the flow of data processing in the apparatus.  
 Fig. 14 shows the plots of the glucose concentration values calculated according to the present invention and the glucose concentration values measured by the enzymatic electrode method.  
 50

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0016]** The invention will now be described by way of preferred embodiments thereof with reference made to the drawings.  
 55 **[0017]** Initially, the above-mentioned model will be described in more specific terms. Regarding the amount of heat dissipation, convective heat transfer, which is one of the main causes of heat dissipation, is related to temperature difference between the ambient (room) temperature and the body-surface temperature. Another main cause of dissipation, namely the amount of heat dissipation due to radiation, is proportional to the fourth power of the body-surface

## EP 1 518 494 A1

temperature according to the Stefan-Boltzmann law. Thus, it can be seen that the amount of heat dissipation from the human body is related to the room temperature and the body-surface temperature. On the other hand, the oxygen supply, which is a major factor related to the amount of heat production, is expressed as the product of hemoglobin concentration, hemoglobin oxygen saturation, and blood flow volume.

5 [0018] The hemoglobin concentration can be measured from the absorbance at the wavelength (equal-absorbance wavelength) at which the molar absorbance coefficient of the oxyhemoglobin is equal to that of the deoxyhemoglobin. The hemoglobin oxygen saturation can be measured by measuring the absorbance at the equal-absorbance wavelength and the absorbance at at least one different wavelength at which the ratio between the molar absorbance coefficient of the oxyhemoglobin and that of the deoxyhemoglobin is known, and then solving simultaneous equations. 10 Namely, the hemoglobin concentration and hemoglobin oxygen saturation can be obtained by conducting the measurement of absorbance at at least two wavelengths. However, in order to accurately determine the hemoglobin concentration and hemoglobin oxygen saturation from absorbance, the influence of interfering components must be corrected. The interfering components affecting the absorbance include the thickness of the skin (epidermis), for example. These interfering components can be measured in various manners, of which one example will be described below.

15 [0019] The thickness of the skin can be measured by measuring the intensity of only that light that has traveled in the skin by a distance  $d$  from where light was shone on the skin. Fig. 1 shows the behavior of light in the case where the skin surface was irradiated with continuous light. As the light of a certain wavelength and intensity is shone, the light is reflected and scattered by the skin surface. Part of the light penetrates the skin and experiences scatterings and diffusion in a repeated manner. In such a behavior of light, the depth of penetration of the light that has traveled 20 by distance  $d$  is substantially constant depending on the wavelength. The skin does not contain blood, so it has a low fluidity, resulting in a low absorbance. On the other hand, the corium contains blood and therefore has a high fluidity, resulting in a high absorbance. Thus, when the skin is thin, the light can penetrate deeper into the corium, resulting in a larger absorbance. When the skin is thick, the distance traveled by the light becomes shorter, so that the absorbance becomes smaller. By taking the ratio between the intensity of only that light that has traveled distance  $d$  and the intensity 25 of the light that has traveled in a standard substance with a known thickness in the same manner, the thickness of the skin can be estimated.

[0020] The measurements are carried out using at least three detectors, namely a reflected light detector for detecting mainly reflected light, a scattered light detector for detecting mainly scattered light, and a traveled photon detector for detecting traveled photon.

30 [0021] The reflected light detector can detect part of the scattered light produced by the light passing inside the body and then exiting from the body surface, as well as detecting the reflected light reflected by the body surface. The scattered light detector can detect part of the scattered light scattered from the body surface, as well as detecting the scattered light produced by the light passing inside the body and then exiting through the body surface. The path of the traveled photon to the traveled photon detector is optically blocked in order to prevent the detection of the light 35 derived from reflected light and scattered light by the traveled photon detector. Thus, the traveled photon detector is adapted to detect only traveled photon, so that the skin thickness can be estimated. During detection, a total of at least three detectors, namely at least one each of the reflected light detector, scattered light detector, and traveled photon detector, are used. Preferably, additional detectors with similar functions and with higher detection sensitivities depending on the kind of wavelength may be used. Further, a traveled photon detector may be added for detecting light 40 that has passed through the detection area, as necessary.

[0022] The wavelength values described herein are most appropriate values for obtaining absorbance for intended purposes, such as for obtaining the absorbance at the equal molar absorbance coefficients, or for obtaining the peak of absorbance. Thus, wavelengths close to those described herein may be used for similar measurements.

45 [0023] The rest is the blood flow volume, which can be measured by various methods. One example will be described below.

[0024] Fig. 2 shows a model for the description of the transfer of heat from the body surface to a solid block having a certain heat capacity when the block is brought into contact with the body surface for a certain time and then separated. The block is made of resin such as plastic or vinyl chloride. In the illustrated example, attention will be focused on the chronological variation of the temperature  $T_1$  of a portion of the block that is brought into contact with the body surface, 50 and the chronological variation of the temperature  $T_2$  of a point on the block away from the body surface. The blood flow volume can be estimated by monitoring mainly the chronological variation of the temperature  $T_2$  (of the spatially separated point on the block). The details will follow.

[0025] Before the block comes into contact with the body surface, the temperatures  $T_1$  and  $T_2$  at the two points of the block are equal to the room temperature  $T_r$ . When a body-surface temperature  $T_s$  is higher than the room temperature  $T_r$ , the temperature  $T_1$  swiftly rises due to the transfer of heat from the skin as the block comes into contact with the body surface, and it approaches the body-surface temperature  $T_s$ . On the other hand, the temperature  $T_2$  is less 55 than the temperature  $T_1$  as the heat conducted through the block is dissipated from the block surface, and it rises gradually. The chronological variation of the temperatures  $T_1$  and  $T_2$  depends on the amount of heat transferred from

## EP 1 518 494 A1

the body surface to the block, which in turn depends on the blood flow volume in the capillary blood vessels under the skin. If the capillary blood vessels are regarded as a heat exchanger, the coefficient of transfer of heat from the capillary blood vessels to the surrounding cell tissues is given as a function of the blood flow volume. Thus, by measuring the amount of heat transfer from the body surface to the block by monitoring the chronological variation of the temperatures  $T_1$  and  $T_2$ , the amount of heat transferred from the capillary blood vessels to the cell tissues can be estimated. Based on this estimation, the blood flow volume can then be estimated.

**[0026]** Fig. 3 shows the chronological variation of the measured values of the temperature  $T_1$  at the portion of the block in contact with the body surface and the temperature  $T_2$  at the position on the block away from the body-surface contact position. As the block comes into contact with the body surface, the  $T_1$  measured value swiftly rises, and it gradually drops as the block is brought out of contact.

**[0027]** Fig. 4 shows the chronological variation of the value of the temperature  $T_3$  measured by a radiation temperature detector. As the detector detects the temperature due to radiation from the body surface, it is more sensitive to temperature changes than other sensors. Because radiation heat propagates as an electromagnetic wave, it can transmit temperature changes instantaneously. Thus, by locating the radiation temperature detector near where the block contacts the body surface to measure radiated heat, as shown in Fig. 8 (which will be described later), the time of start of contact  $t_{\text{start}}$  and the time of end of contact tend between the block and the body surface can be detected from changes in the temperature  $T_3$ . For example, a temperature threshold value is set as shown in Fig. 4. The contact start time  $t_{\text{start}}$  is when the temperature threshold value is exceeded. The contact end time tend is when the temperature  $T_3$  drops below the threshold. The temperature threshold value is set at 32°C, for example.

**[0028]** Then, the  $T_1$  measured value between  $t_{\text{start}}$  and  $t_{\text{end}}$  is approximated by an S curve, such as a logistic curve. A logistic curve is expressed by the following equation:

$$T = \frac{b}{1 + c \times \exp(-a \times t)} + d$$

where  $T$  is temperature, and  $t$  is time.

**[0029]** The measured value can be approximated by determining coefficients  $a$ ,  $b$ ,  $c$ , and  $d$  by the non-linear least-squares method. For the resultant approximate expression,  $T$  is integrated between time  $t_{\text{start}}$  and time  $t_{\text{end}}$  to obtain a value  $S_1$ .

**[0030]** Similarly, an integrated value  $S_2$  is calculated from the  $T_2$  measured value. The smaller ( $S_1 - S_2$ ) is, the larger the amount of transfer of heat from the body surface to the position of  $T_2$ . ( $S_1 - S_2$ ) becomes larger with increasing body surface contact time  $t_{\text{cont}}$  ( $=t_{\text{end}} - t_{\text{start}}$ ). Thus,  $a_5/(t_{\text{cont}} \times (S_1 - S_2))$  is designated as a parameter  $X_5$  indicating the volume of blood flow, using  $a_5$  as a proportionality coefficient.

**[0031]** Thus, it will be seen that the measured amounts necessary for the determination of blood glucose concentration by the above-described model are the room temperature (ambient temperature), body surface temperature, temperature changes in the block brought into contact with the body surface, the temperature due to radiation from the body surface, the absorbance of reflected light or scattered light at at least two wavelengths, and the intensity of traveled photon.

**[0032]** Fig. 5 shows the relationships between the measured values provided by various sensors and the parameters derived therefrom. A block is brought into contact with the body surface, and chronological changes in two kinds of temperatures  $T_1$  and  $T_2$  are measured by two temperature sensors provided at two locations of the block. Separately, radiation temperature  $T_3$  on the body surface and room temperature  $T_4$  are measured. Absorbance  $A_1$  and  $A_2$  of scattered light and reflected light, respectively, are measured at at least two wavelengths related to the absorption of hemoglobin. The intensity  $I_1$  of traveled photon is measured at at least one wavelength. Alternatively, the intensity may be measured by the aforementioned two wavelengths, so that their averaged or median value can be used. The temperatures  $T_1$ ,  $T_2$ ,  $T_3$ , and  $T_4$  provide parameters related to the volume of blood flow. The temperature  $T_3$  provides a parameter related to the amount of heat transferred by radiation. The temperatures  $T_3$  and  $T_4$  provide parameters related to the amount of heat transferred by convection. The absorbance  $A_1$  and  $A_2$  and intensity  $I_1$  provide parameters related to the hemoglobin concentration and the hemoglobin oxygen saturation.

**[0033]** Hereafter, an example of apparatus for non-invasively measuring blood sugar levels according to the principle of the invention will be described.

**[0034]** Fig. 6 shows a top plan view of a non-invasive blood sugar level measuring apparatus according to the invention. While in this example the skin on the ball of the finger tip is used as the body surface, other parts of the body surface may be used.

**[0035]** On the top surface of the apparatus are provided an operating portion 11, a measuring portion 12 where the finger to be measured is to be placed, and a display portion 13 for displaying measurement results, the state of the apparatus, measured values, for example. The operating portion 11 includes four push buttons 11a to 11d for operating the apparatus. The measuring portion 12 has a cover 14 which, when opened (as shown), reveals a finger rest portion

## EP 1 518 494 A1

15 with an oval periphery. The finger rest portion 15 accommodates an opening end 16 of a radiation temperature sensor portion, a contact temperature sensor portion 17, and an optical sensor portion 18.

[0036] Fig. 7 shows the procedure for operating the apparatus. As one of the buttons on the operating portion is pressed to turn on the apparatus, an indication "Warming up" is displayed on the LCD while the electronic circuits in the apparatus are being warmed up. At the same time, a check program is activated to automatically check the electronic circuits. As the warm-up phase is over, an indication "Place your finger" appears on the LCD. As the user places his or her finger on the finger rest portion, a countdown is displayed on the LCD. When the countdown is over, an indication "Put your finger away" appears on the LCD. As the user follows the instruction, the LCD indicates "Processing data." Thereafter, the display shows the blood sugar level, which is then stored in an IC card together with the date and time. After the user took notes of the displayed blood sugar level, he or she pushes another button on the operating portion. About one minute later, the apparatus displays a message "Place your finger" on the LCD, thus indicating that the apparatus is ready for the next cycle of measurement.

[0037] Fig. 8 shows the measuring portion in detail. In Fig. 8, (a) is a top plan view, (b) is a cross section taken along line X-X of (a), (c) is a cross section taken along line Y-Y of (a), and (d) is a cross section taken along Z-Z of (a).

[0038] First, the process of measuring temperatures by the non-invasive blood sugar level measuring apparatus according to the invention will be described. In the portion of the measuring portion where the examined portion (ball of the finger) is to come into contact, a thin plate 21 of a highly heat-conductive material, such as gold, is placed. A bar-shaped heat-conductive member 22 made of material such as polyvinylchloride whose heat conductivity is lower than that of the plate 21 is thermally connected to the plate 21 and extends into the apparatus. The temperature sensors include a thermistor 23 for measuring the temperature of the plate 21 and acting as an adjacent-temperature detector with respect to the examined portion. There is also a thermistor 24 for measuring the temperature of a portion of the heat-conducting member which is distanced away from the plate 21 by a certain distance and acting as an indirect-temperature detector with respect to the examined portion. An infrared lens 25 is disposed inside the apparatus at such a position that the examined portion (ball of the finger) placed on the finger rest portion 15 can be seen through the lens. Below the infrared lens 25 is disposed a pyroelectric detector 27 via an infrared radiation-transmitting window 26. Another thermistor 28 is disposed near the pyroelectric detector 27.

[0039] Thus, the temperature sensor portion of the measuring portion has four temperature sensors, and they measure four kinds of temperatures as follows:

- (1) Temperature on the finger surface (thermistor 23):  $T_1$
- (2) Temperature of the heat-conducting member (thermistor 24):  $T_2$
- (3) Temperature of radiation from the finger (pyroelectric detector 27):  $T_3$
- (4) Room temperature (thermistor 28):  $T_4$

[0040] The optical sensor portion 18 measures the hemoglobin concentration and the hemoglobin oxygen saturation necessary for the determination of the oxygen supply volume. In order to measure the hemoglobin concentration and the hemoglobin oxygen saturation accurately, it is necessary to measure the absorbance of scattered light at at least two wavelengths, the absorbance of reflected light at at least one wavelength, and the intensity of traveled photon at at least one wavelength. The accuracy of the absorbance of reflected light can be improved by measuring at a plurality of wavelengths, if possible, and then using a mean value. Thus, in the present embodiment, the absorbance of reflected light is measured at two different wavelengths. The accuracy of the measurement of the intensity of traveled photon can also be improved by measuring at a plurality of wavelengths, if possible, and then using a mean value. Figs. 8(b) to 8(g) show configurations for carrying out the measurement using two light sources 36 and 37 and three detectors 38 to 40.

[0041] The ends of five optical fibers 31 to 35 are located in the optical sensor portion 18. The optical fibers 31 and 32 are for optical irradiation, while the optical fibers 33 to 35 are for receiving light. As shown in Fig. 8(c), the optical fiber 31 connects to a branch fiber 31a that is provided with a light-emitting diode 36 of a wavelength at the end thereof. Similarly, the optical fiber 32 is connected to a branch optical fiber 32a at the end of which is disposed a light-emitting diode 37 of a wavelength. The other end of the light-receiving optical fiber 33 is provided with a photodiode 38. The other end of the light-receiving optical fiber 34 is provided with a photodiode 39. The other end of the light-receiving optical fiber 35 is provided with a photodiode 40. To the optical fiber 31 or 32 may be connected a plurality of branch optical fibers at the ends of which are disposed light-emitting diodes. The light-emitting diode 36 emits light with a wavelength of 810 nm, while the light-emitting diode 37 emits light with a wavelength of 950 nm. The wavelength 810 nm is the equal absorbance wavelength at which the molar absorbance coefficient of the oxyhemoglobin is equal to that of the deoxyhemoglobin. The wavelength 950 nm is the wavelength at which the difference between the molar absorbance coefficient of the oxyhemoglobin and that of the deoxyhemoglobin is large.

[0042] The two light-emitting diodes 36 and 37 emit light in a time-sharing manner. The finger of an examined subject is irradiated with the light emitted by the light-emitting diodes 36 and 37 via the irradiating optical fibers 31 and 32. The

## EP 1 518 494 A1

light shone on the finger from the light-irradiating optical fiber 31 is reflected by the skin, and the reflected light enters the light-receiving optical fiber 33, and is eventually detected by the photodiode 38. The scattered light enters the light-receiving optical fiber 34 and is then detected by the photodiode 39. The traveled photon enters the light-receiving optical fiber 35 and is then detected by the photodiode 40. The light-receiving optical fiber 35 is adapted to be in close contact with the finger surface such that it can avoid the direct entry of reflected and/or scattered light. The light with which the finger is irradiated via the light-irradiating optical fiber 32 is reflected by the skin of the finger, and the reflected light is incident on the light-receiving optical fiber 34 and is then detected by the photodetector 39. The scattered light is incident on the light-receiving optical fiber 33 and is then detected by the photodiode 38. The traveled photon is incident on the light-receiving optical fiber 35 and is then detected by the photodiode 40. Thus, by causing the two light-emitting diodes 36 and 37 to emit light in a time-divided manner, the photodiodes 38 and 39 can detect different light depending on the irradiating position of the light-irradiating optical fiber. By this structure, the number of light-receiving optical fibers can be reduced and the size of the optical sensor portion 18 can be also reduced. Preferably, the light-receiving optical fiber 35 may be adapted not to detect the light with which the finger is irradiated via the light-irradiating optical fiber 32.

**[0043]** It is also possible to dispose the photodiodes 38 and 39 directly at the positions corresponding to each end of the light-receiving optical fibers 33 and 34, respectively, without using the light-receiving optical fibers 33 and 34, as shown in Figs. 8(e) and 8(f), which correspond to Figs. 8(c) and 8(d), respectively. In such an arrangement, the amount of light detected by each photodiode can be increased. Regarding the light-receiving optical fiber 35, it is similarly possible to increase the amount of received light by disposing the photodiode 40 directly at the position corresponding to the end of the light-receiving optical fiber 35. However, putting the photodiode 40 directly at the end of the light-receiving optical fiber 35 would result in an increased size of the optical sensor portion 18. Accordingly, it is desirable to use the light-receiving optical fiber 35 if the size of the optical sensor portion 18 is to be reduced.

**[0044]** Fig. 9 shows a block diagram of an example of the circuit for causing the light-emitting diodes to emit in a time-divided manner. A controller 1 causes the light-emitting diodes 36 and 37 in a time-divided manner by repeating the following steps (1) and (2). Fig. 9 concerns the case of using two wavelengths (two LEDs).

(1) Sends a control signal 1 in synchronism with a clock sent from a clock generator to a controller 2 for a certain duration of time for selecting a control signal 2. As a result, a switching circuit 51 is turned on, thereby turning power on and causing the light-emitting diode 36 to emit light.

(2) After a certain duration of time has elapsed, sends a control signal 1 to the controller 2 for a certain duration of time in synchronism with a clock from the clock generator in order to select a control signal 3. As a result, a switching circuit 52 is turned on, thereby turning power on and causing the light-emitting diode 37 to emit light.

**[0045]** It is also possible to cause the two light-emitting diodes 36 and 37 to emit substantially simultaneously, as shown in Figs. 10(a) to (d), rather than in a time-divided manner. By using spectroscopes 41 a, 41b, and 41c including a prism or a diffraction grating, for example, the light of individual wavelengths is divided into individual spectral components. The light with which the finger has been irradiated via the light-irradiating optical fiber 31 is reflected by the finger skin, and the light including the reflected light is incident on the light-receiving optical fiber 33 and is then separated by the spectroscope 41a. The separated reflected light is incident on the light-receiving optical fiber 33a and is then detected by the photodiode 38a. The light including scattered light is incident on the light-receiving optical fiber 34 and is then separated into individual spectral components by the spectroscope 41b. The separated scattered light is incident on the light-receiving optical fiber 34a and is then detected by the photodiode 39a.

**[0046]** The light with which the finger has been irradiated via the light-irradiating optical fiber 32 is reflected by the finger skin, and the light including the reflected light is incident on the light-receiving optical fiber 34 and is then separated by the spectroscope 41b. The separated reflected light is incident on the light-receiving optical fiber 34b and is then detected by the photodiode 39b. The light including scattered light is incident on the light-receiving optical fiber 33 and is then separated into individual spectral components by the spectroscope 41 a. The separated scattered light is incident on the light-receiving optical fiber 33b and is then detected by the photodiode 38b.

**[0047]** The light including traveled photon of a plurality of wavelengths is incident on the light-receiving optical fiber 35 and is then separated by the spectroscope 41c. The separated traveled photon deriving from the light with which the finger has been irradiated via the light-irradiating optical fiber 31 is incident on the light-receiving optical fiber 35a and is then detected by the photodiode 40a. The separated traveled photon deriving from the light with which the finger has been irradiated via the light-irradiating optical fiber 32 is incident on the light-receiving optical fiber 35b and is then detected by the photodiode 40b.

**[0048]** There are other methods of separating and detecting light from a plurality of light sources. For example, the individual light sources may be modulated with different modulation frequencies, such that light from each light source can be separated and detected on the basis of the frequency components contained in a detection signal from photodetectors.

## EP 1 518 494 A1

**[0049]** The light-irradiating optical fibers and the light-receiving optical fibers are disposed in the optical sensor portion 18 based on the following theories (1) to (3).

(1) Regarding the positioning of the light-receiving optical fiber for reflected light relative to the light-irradiating optical fiber, it is most appropriate theoretically to position the light-receiving end of the light-receiving optical fiber at a position where the reflected light is received, namely within the plane of incidence of light on the subject, such that it can receive light reflected in a direction with an outgoing angle that is equal to the angle of incidence on a light-incident point of the subject. By locating the light-receiving optical fiber at such a position, the ratio of reflected light in the amount of received light can be maximized.

(2) The light-receiving end of the light-receiving optical fiber for scattered light is disposed in a plane displaced by approximately  $90^\circ$  with respect to the plane of incidence of light on the subject. The light-receiving optical fiber for scattered light is thus disposed at approximately  $90^\circ$  relative to the reflected-light receiving optical fiber because the source of light detected as scattered light should be narrowed to the scattering phenomena as much as possible, as opposed to theory (1), and also because the range of phenomena as the object of detection of scattering should be increased by the provision of the large angle of approximately  $90^\circ$ .

(3) The light-receiving end of the light-receiving optical fiber for traveled photon is disposed at a position, within the plane of incidence of light on the subject, that is farther than the light-receiving end of the reflected-light receiving optical fiber from the light-irradiating optical fiber. The light-receiving end of the traveled-photon receiving optical fiber is thus disposed within the plane of incidence of light on the subject for the following reason. During the process in which light enters the skin and is scattered inside, the distribution of light spreads, and yet the distribution is greatest in the direction of incidence. As a result, the amount of light exiting from the skin is also greatest in this direction, so that the traveled photon can be most efficiently detected at the aforementioned position. Further, the light-receiving end of the traveled-photon receiving optical fiber is disposed farther than the light-receiving end of the reflected-light receiving optical fiber from the light-irradiating optical fiber. By so doing, a large amount of information can be obtained that relates to the absorption of light by hemoglobin in blood flowing in the capillary blood tubes during the process of light penetrating the skin and being scattered inside, or that relates to the thickness of skin, for example. It is also possible, however, to dispose the light-receiving optical fiber for traveled photon at positions other than that within the plane of incidence of light on the subject, though in that case the amount of traveled photon that is detected would be less.

**[0050]** In accordance with those theories (1) to (3), the outgoing end of the light-irradiating optical fiber and the receiving end of the light-receiving optical fiber are disposed in the optical sensor portion 18 as shown in the plan view of Fig. 11 (a). In this plan view, the light-irradiating optical fiber 31, the reflected-light receiving optical fiber 33 and the traveled-photon receiving optical fiber 35 are disposed substantially along an identical line XX. On a line YY with an angle  $\alpha$  of approximately  $90^\circ$  with respect to the line XX connecting the light-irradiating optical fiber 31 and reflected-light receiving optical fiber 33, there are disposed the light-irradiating optical fiber 32 and the light-receiving optical fiber 34 for scattered light from the light-irradiating optical fiber 31. The light-irradiating optical fibers 31 and 32 and the light-receiving optical fibers 33 and 34 are disposed more or less on an identical circle P about a center where the lines XX and YY intersect.

**[0051]** Regarding the angles of irradiation and detection of light by the light-irradiating optical fiber 31 and the light-receiving optical fiber 33, the light-irradiating optical fiber 31 and the light-receiving optical fiber 33 are disposed such that angles  $\theta$  and  $\phi$  shown in Fig. 8(g) are substantially identical. Specifically, the angle  $\theta$  is the angle of incidence made by the axis of the light-irradiating optical fiber 31 and a normal to the surface of the subject at a point  $\gamma$  of incidence (light incident point) above the point of intersection of the lines XX and YY shown in Fig. 11 (a). The angle  $\phi$  is the angle the light reflected at the incident point  $\gamma$  makes with the normal.

**[0052]** By thus disposing the light-irradiating optical fiber 31, the light-receiving optical fiber 33 and the traveled-light receiving optical fiber 35 along the same line, the amount of traveled photon detected by the light-receiving optical fiber 35 can be maximized. However, since the light-receiving optical fiber 35 is disposed in the same direction as the direction in which light is emitted from the light-irradiating optical fibers 31 and 32, the ratios of reflected light or scattered light in the amount of received light increase. Further, as the light-receiving optical fiber 33, the plate 21, the heat-conducting member 22 connected thereto and thermistor 24 are disposed along an identical line, the plate 21 and the heat-conducting member 22 and thermistor 24 connected thereto must be disposed away from the light-receiving optical fiber 33 along the line XX in order to allow the optical fiber 33 to be disposed. As a result, the size of the optical sensor portion shown in Fig. 11 (a) increases.

**[0053]** The outgoing end of the light-irradiating optical fiber and the receiving end of the light-receiving optical fiber may be disposed in the optical sensor portion 18 as shown in a plan view of Fig. 11 (b), in accordance with the theories (1) to (3). In the plan view, the light-irradiating optical fiber 31 and the reflected-light receiving optical fiber 33 are disposed along the identical line XX. On a line YY with an angle of approximately  $90^\circ$  with respect to the line XX

## EP 1 518 494 A1

connecting the light-irradiating optical fiber 31 and reflected-light receiving optical fiber 33, there are disposed the light-irradiating optical fiber 32 and the light-receiving optical fiber 34 for scattered light from the light-irradiating optical fiber 31. The traveled-photon receiving optical fiber 35 is disposed along a line ZZ that intersects the line YY at an angle of approximately 45°. The light-irradiating optical fibers 31 and 32 and the light-receiving optical fibers 33 and 34 are disposed more or less on an identical circle P about a center where the lines XX and YY intersect. Regarding the angles of irradiation and detection of light by the light-irradiating optical fiber 31 and the light-receiving optical fiber 33, the light-irradiating optical fiber 31 and the light-receiving optical fiber 33 are disposed such that angles  $\theta$  and  $\phi$  shown in Fig. 8(g) are substantially identical. Specifically, the angle  $\theta$  is the angle of incidence made by the axis of the light-irradiating optical fiber 31 and a normal to the surface of the subject at a point  $\gamma$  of incidence (light incident point) above the point of intersection of the lines XX and YY shown in Fig. 11(b). The angle  $\phi$  is the angle the light reflected at the incident point  $\gamma$  makes with the normal.

**[0054]** By thus disposing the traveled-photon detecting optical fiber 35 on the line ZZ as shown in Fig. 11 (b), though the amount of traveled photon that can be detected by the light-receiving optical fiber 35 decreases, the distance between the point of intersection of the lines XX and YY and the light-receiving optical fiber 35 can be reduced in the line ZZ direction. Accordingly, the size of the optical sensor portion 18 can be reduced. Further, as the light-receiving optical fiber 35 is disposed at a position approximately 45° away from the direction in which the light-irradiating optical fibers 31 and 32 radiate, the influence of reflected light or scattered light can be minimized, so that a large amount of traveled photon can be detected in the amount of received light.

**[0055]** The outgoing end of the light-irradiating optical fiber and the receiving end of the light-receiving optical fiber in the optical sensor portion 18 can be disposed as shown in a plan view of Fig. 11 (c), in accordance with the theories (1) to (3). Namely, the light-irradiating optical fibers 31 and 32 and the light-receiving optical fibers 33 and 34 may be disposed at any positions on a circle P with a center  $\beta$  and a radius corresponding to the line between the center  $\beta$  and the light-irradiating optical fiber 31 on the condition that the line XX intersects the line YY at an angle of approximately 90°. For example, as shown in Fig. 11 (c), the optical sensor portion 18 may be configured in the following manner. The light-irradiating optical fiber 31 is disposed at a position corresponding to that of the light-receiving optical fiber 33 of Fig. 11(b), and the light-receiving optical fiber 33 is disposed at a position corresponding to that of the light-irradiating optical fiber 31 of Fig. 11 (b). The light-irradiating optical fiber 32 is disposed at a position corresponding to that of the light-receiving optical fiber 34 of Fig. 11(b), and the light-receiving optical fiber 34 is disposed at a position corresponding to that of the light-irradiating optical fiber 32 of Fig. 11 (b). The traveled-photon receiving optical fiber 35 is disposed on line ZZ that intersects line YY at approximately 45°. Regarding the angles of irradiation and detection of light by the light-irradiating optical fiber 31 and the light-receiving optical fiber 33, the light-irradiating optical fiber 31 and the light-receiving optical fiber 33 are disposed such that angles  $\theta$  and  $\phi$  shown in Fig. 8(g) are substantially identical. Specifically, the angle  $\theta$  is the angle of incidence made by the axis of the light-irradiating optical fiber 31 and a normal to the surface of the subject at a point  $\gamma$  of incidence (light incident point) above the point of intersection of the lines XX and YY shown in Fig. 11 (c). The angle  $\phi$  is the angle the light reflected at the incident point  $\gamma$  makes with the normal.

**[0056]** In this arrangement, the traveled-light detecting optical fiber 35 is positioned in a direction opposite to that in which the light-irradiating optical fibers 31 and 32 radiate, so that, although the amount of light received by the light-receiving optical fiber 35 is fairly small, the received light hardly contains reflected light or scattered light and consists mostly of traveled photon.

**[0057]** Regarding the arrangement of the light-irradiating optical fiber and light-receiving optical fiber in the optical sensor portion 18 shown in Figs. 11 (a) to (c), a branch optical fiber 32a may be connected to the light-irradiating optical fiber 31, and a light-emitting diode 37 may be disposed at the end of the optical fiber 32a, instead of using the light-irradiating optical fiber 32. A top view of this arrangement of the optical fibers and the light-emitting diode is shown in Fig. 11 (d). Fig. 11 (e) is a cross section taken along line XX of Fig. 11 (d), and Fig. 11 (f) is a cross section taken along line YY. The ZZ cross section of Fig. 11 (d) is similar to that of Fig. 8(b).

**[0058]** Regarding the optical sensor portion 18, the outgoing end or receiving end of the light-irradiating optical fibers 31 and 32 and the light-receiving optical fibers 33 and 34 may be displaced in axial direction of the optical fibers as long as they are aimed at the light incident point  $\gamma$  on the subject (see Fig. 8(g)). In that case, the light-irradiating optical fibers 31 and 32 and the light-receiving optical fibers 33 and 34 would not be all disposed on the identical circle P as shown but would be displaced from one another in the height direction. However, if the light-irradiating optical fibers 31 and 32 are disposed at different heights, the intensity of irradiated light would be large near the body surface and would be low away from the body surface. Further, if the light-receiving optical fibers 33 and 34 are disposed at different heights, the intensity of received light would increase near the body surface and would decrease away from the body surface due to the spreading of light. Thus, such an arrangement would make it difficult to carry out measurement in a homogeneous environment and a correction of the information detected by the photodiodes would be necessary. In general, the light-irradiating optical fibers and the light-receiving optical fibers are disposed near where light is irradiated so that an accurate measurement can be conducted. In the configuration of the present invention, the light-irradiating optical fibers and the light-receiving optical fibers are disposed as close to the body surface as possible without hin-

## EP 1 518 494 A1

dering other functions for measurements such as one for temperature. Further, the light-irradiating optical fibers 31 and 32 and the light-receiving optical fibers 33 and 34 are disposed on the identical circle P and, generally, near the plane of a cone whose apex is at the light incident point  $\gamma$ , such that a homogeneous environment for measuring radiated light and detected light can be obtained and an accurate measurement can be conducted.

**[0059]** Further regarding the optical sensor portion 18 shown in Figs. 11 (a) to Fig. 11(d), the traveled-photon receiving optical fiber 35 may be disposed at any point on a circle with a center  $\beta$  and a radius corresponding to the line connecting the center  $\beta$  and the light-receiving optical fiber 35, as indicated by a dashed line in Fig. 11 (g). In this case, the distance between the outgoing end (the light incident point) of the light-irradiating optical fiber and the receiving end of the light-receiving optical fiber 35 (namely, the end on which the light as the object of reception is incident) would be larger than the distance between the light incident point and the reception end of the light-receiving optical fiber 33 or the receiving end of the light-receiving optical fiber 34. In such an arrangement, the placement of the traveled-photon receiving optical fiber 35 can be freely set, so that the optical sensor portion 18 can be configured in various ways as needed.

**[0060]** The photodiodes 38 and 39 provide reflectance R as measurement data, and absorbance can be approximately calculated from  $\log(1/R)$ . Light of wavelengths 810 nm and 950 nm is irradiated; and R is measured for each and  $\log(1/R)$  is obtained for each, so that absorbance  $A_{D11}$  and  $A_{D21}$  at wavelength 810 nm and absorbance  $A_{D12}$  and  $A_{D22}$  at wavelength 950 nm can be measured. Part of the light penetrates into the skin and is transmitted by a certain distance d while being scattered therein repeatedly. The intensity  $I_{D3i}$  of traveled photon is measured by a photodiode 40. (The absorbance of reflected light of wavelength  $\lambda_i$  detected by the photodiode for detecting reflected light is referenced by  $A_{D1i}$ , the absorbance of scattered light of wavelength  $\lambda_i$  detected by the photodiode for detecting scattered light is referenced by  $A_{D2i}$ , and the intensity of traveled photon of wavelength  $\lambda_i$  detected by the photodiode 40 is referenced by  $I_{D3i}$ .)

**[0061]** When the deoxyhemoglobin concentration is [Hb], the oxyhemoglobin concentration is  $[HbO_2]$ , scattered-light absorbance  $A_{D2i}$  at wavelength  $\lambda_i$  is expressed by the following equations:

$$A_{D2i} = a \{ [Hb] \times A_{Hb}(\lambda_i) + [HbO_2] \times A_{HbO_2}(\lambda_i) \} \times D \times a_R$$

$$a_R = \frac{b \times \sum A_{D2i}}{\sum A_{D1i}}, \quad D = \frac{1}{\frac{c \times \sum I_{D3i}}{i}}$$

where  $A_{Hb}(\lambda_i)$  and  $A_{HbO_2}(\lambda_i)$  are the molar absorbance coefficients of the deoxyhemoglobin and the oxyhemoglobin, respectively, and are known at the respective wavelengths. Terms a, b, and c are proportionality coefficients.  $A_{D1i}$  is the reflected-light absorbance at wavelength  $\lambda_i$ , and  $I_{D3i}$  is the traveled photon intensity of wavelength  $\lambda_i$ . From the above equations, the parameter  $a_R$ , which is determined by the relationship between reflected light and scattered light, and the parameter D of the skin thickness can be determined as constants, and can be substituted in the equation of  $A_{D2i}$ . Using the parameter determined by the relationship between reflected light and scattered light, such as the parameter relating to the roughness of the skin surface, the influence of the roughness of the skin surface, for example, can be corrected. The parameter relating to the thickness of the skin can be determined from the measurement value obtained by the traveled photon detector, so that the influence of the thickness of the skin can be corrected. Since  $i=2$ , two equations of  $A_{D2i}$  are produced. By solving these simultaneous equations, the two variables to be obtained, namely [Hb] and  $[HbO_2]$ , can be obtained. The hemoglobin concentration  $[Hb] + [HbO_2]$ , and the hemoglobin oxygen saturation  $[HbO_2]/([Hb] + [HbO_2])$  can be determined from the above-obtained [Hb] and  $[HbO_2]$ .

**[0062]** In the present example, the hemoglobin concentration and the hemoglobin oxygen saturation are measured by measuring absorbance at two wavelengths. Preferably, however, absorbance may be measured by adding one or more wavelengths at which the difference in molar absorbance coefficient between the oxyhemoglobin and the deoxyhemoglobin is large, so that the measurement accuracy can be further improved.

**[0063]** On the assumption that six wavelengths are used for measurement, any of the configurations shown in Figs. 11(a) to 11(c) may be employed for the arrangement of the light-irradiating optical fibers and the light-receiving optical fibers in the optical sensor portion 18 in accordance with the theories (1) to (3). However, in the case of six wavelengths, while the ZZ cross-section of Fig. 11(b) corresponds to Fig. 8(b), the XX cross-section of Fig. 11(b) corresponds to Fig. 12(a), and the YY cross-section of Fig. 11(b) corresponds to Fig. 12(b). To the light-irradiating optical fiber 31 are connected three branch optical fibers 31a, 31b and 31c at the end of each of which are disposed light-emitting diodes 36a, 36b and 36c, respectively. Likewise, three branch optical fibers 32a, 32b and 32c are connected to the light-irradiating optical fiber 32, and light-emitting diodes 37a, 37b and 37c are connected to the ends of the respective branch optical fibers. Thus, three optical fibers are connected to each light-irradiating optical fiber, so that the size of



## EP 1 518 494 A1

the optical sensor portion 18 can be reduced. The light-emitting diode 36a emit light of 810 nm, light-emitting diode 36b emit light of 880 nm, light-emitting diode 36c emit light of 950 nm, light-emitting diode 37a emit light of 450 nm, light-emitting diode 37b emit light of 520 nm, and light-emitting diode 37c emit light of 660 nm, for example. Using the result of detection of irradiated light having these six wavelengths, corrections can be made for the influences of interfering components on the determination of hemoglobin concentration and hemoglobin oxygen saturation from absorbance, the interfering components including melanin pigment, bilirubin and the turbidity of blood, for example. Thus, the accuracy of measurement can be improved.

**[0064]** Fig. 13 shows how data is processed in the apparatus using two wavelengths. The apparatus according to the present example is equipped with thermistor 23, thermistor 24, pyroelectric detector 27, thermistor 28, and three photodetectors formed by photodiodes 38 to 40. The photodiodes 38 and 39 measure absorbance at wavelengths 810 nm and 950 nm. The photodiode 40 measures the intensity at wavelengths 810 nm and 950 nm. Thus, the apparatus is supplied with ten kinds of measurement values including temperature, heat, and optical measurement data. In the case where the wavelength 880 nm is added for improving accuracy, the number of measurement values fed to the apparatus would be 13.

**[0065]** The seven kinds of analog signals are supplied via individual amplifiers A1 to A7 to analog/digital converters AD1 to AD7, where they are converted into digital signals. Based on the digitally converted values, parameters  $x_i$  ( $i=1, 2, 3, 4, 5$ ) are calculated. The following are specific descriptions of  $x_i$  (where  $e_1$  to  $e_5$  are proportionality coefficients):

Parameter proportional to heat radiation

$$x_1 = e_1 \times (T_3)^4$$

Parameter proportional to heat convection

$$x_2 = e_2 \times (T_4 - T_3)$$

Parameter proportional to hemoglobin concentration

$$x_3 = e_3 \times ([Hb] + [HbO_2])$$

Parameter proportional to hemoglobin oxygen saturation

$$x_4 = e_4 \times \left( \frac{[HbO_2]}{[Hb] + [HbO_2]} \right)$$

Parameter proportional to blood flow volume

$$x_5 = e_5 \times \left( \frac{1}{t_{CONT} \times (S_1 - S_2)} \right)$$

**[0066]** Then, normalized parameters are calculated from mean values and standard deviations of parameter  $x_i$  obtained from actual data pertaining to large numbers of able-bodied people and diabetic patients. A normalized parameter  $X_i$  (where  $i=1, 2, 3, 4, 5$ ) is calculated from each parameter  $x_i$  according to the following equation:

$$X_i = \frac{x_i - \bar{x}_i}{SD(x_i)}$$

where

## EP 1 518 494 A1

$x_i$ : parameter

$\bar{x}_i$ : mean value of the parameter

$SD(x_i)$ : standard deviation of the parameter

5 [0067] Using the above five normalized parameters, calculations are conducted for conversion into glucose concentration to be eventually displayed. A program necessary for the processing calculations is stored in a ROM in the microprocessor built inside the apparatus. The memory region required for the processing calculations is ensured in a RAM similarly built inside the apparatus. The results of calculation are displayed on the LCD.

10 [0068] The ROM stores, as a constituent element of the program necessary for the processing calculations, a function for determining glucose concentration C in particular. The function is defined as follows. C is expressed by the below-indicated equation (1), where  $a_i$  ( $i=0, 1, 2, 3, 4, 5$ ) is determined from a plurality of pieces of measurement data in advance according to the following procedure:

15 (1) A multiple regression equation is created that indicates the relationship between the normalized parameters and the glucose concentration C.

(2) Normalized equations (simultaneous equations) relating to the normalized parameters are obtained from equations obtained by the least-squares method.

(3) Values of coefficient  $a_i$  ( $i=0, 1, 2, 3, 4, 5$ ) are determined from the normalized equations and then substituted into the multiple regression equation.

20 [0069] Initially, the regression equation (1) indicating the relationship between the glucose concentration C and the normalized parameters  $X_1, X_2, X_3, X_4$ , and  $X_5$  is formulated.

25

$$C = f(X_1, X_2, X_3, X_4, X_5)$$

$$= a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 \quad \text{.....(1)}$$

30 [0070] Then, the least-squares method is employed to obtain a multiple regression equation that would minimize the error with respect to a measured value  $C_i$  of glucose concentration according to an enzyme electrode method. When the sum of squares of the residual is E, E is expressed by the following equation (2):

35

$$E = \sum_{i=1}^n d_i^2$$

$$= \sum_{i=1}^n (C_i - f(X_{i1}, X_{i2}, X_{i3}, X_{i4}, X_{i5}))^2$$

40

$$= \sum_{i=1}^n \{C_i - (a_0 + a_1X_{i1} + a_2X_{i2} + a_3X_{i3} + a_4X_{i4} + a_5X_{i5})\}^2 \quad \text{.....(2)}$$

45 [0071] The sum E of squares of the residual becomes minimum when partial differentiation of equation (2) with respect to  $a_0, a_1, \dots, a_5$  gives zero. Thus, we have the following equations:

50

55

## EP 1 518 494 A1

$$\begin{aligned}
\frac{\partial E}{\partial a_0} &= -2 \sum_{i=1}^n \{C_i - (a_0 + a_1 X_{i1} + a_2 X_{i2} + a_3 X_{i3} + a_4 X_{i4} + a_5 X_{i5})\} = 0 \\
\frac{\partial E}{\partial a_1} &= -2 \sum_{i=1}^n X_{i1} \{C_i - (a_0 + a_1 X_{i1} + a_2 X_{i2} + a_3 X_{i3} + a_4 X_{i4} + a_5 X_{i5})\} = 0 \\
\frac{\partial E}{\partial a_2} &= -2 \sum_{i=1}^n X_{i2} \{C_i - (a_0 + a_1 X_{i1} + a_2 X_{i2} + a_3 X_{i3} + a_4 X_{i4} + a_5 X_{i5})\} = 0 \\
\frac{\partial E}{\partial a_3} &= -2 \sum_{i=1}^n X_{i3} \{C_i - (a_0 + a_1 X_{i1} + a_2 X_{i2} + a_3 X_{i3} + a_4 X_{i4} + a_5 X_{i5})\} = 0 \\
\frac{\partial E}{\partial a_4} &= -2 \sum_{i=1}^n X_{i4} \{C_i - (a_0 + a_1 X_{i1} + a_2 X_{i2} + a_3 X_{i3} + a_4 X_{i4} + a_5 X_{i5})\} = 0 \\
\frac{\partial E}{\partial a_5} &= -2 \sum_{i=1}^n X_{i5} \{C_i - (a_0 + a_1 X_{i1} + a_2 X_{i2} + a_3 X_{i3} + a_4 X_{i4} + a_5 X_{i5})\} = 0 \quad \dots\dots(3)
\end{aligned}$$

[0072] When the mean values of C and  $X_1$  to  $X_5$  are  $C_{mean}$  and  $X_{1mean}$  to  $X_{5mean}$ , respectively, since  $X_{imean}=0$  ( $i=1$  to 5), equation (1) provides:

$$\begin{aligned}
a_0 &= C_{mean} - a_1 X_{1mean} - a_2 X_{2mean} - a_3 X_{3mean} - a_4 X_{4mean} - a_5 X_{5mean} \\
&= C_{mean} \quad \dots\dots(4)
\end{aligned}$$

[0073] The variation and covariation between the normalized parameters are expressed by equation (5). Covariation between the normalized parameter  $X_i$  ( $i=1$  to 5) and C is expressed by equation (6).

$$S_{ij} = \sum_{k=1}^n (X_{ki} - X_{imean})(X_{kj} - X_{jmean}) = \sum_{k=1}^n X_{ki} X_{kj} \quad (i, j = 1, 2, \dots, 5) \quad \dots\dots(5)$$

$$S_{iC} = \sum_{k=1}^n (X_{ki} - X_{imean})(C_k - C_{mean}) = \sum_{k=1}^n X_{ki} (C_k - C_{mean}) \quad (i = 1, 2, \dots, 5) \quad \dots\dots(6)$$

[0074] Substituting equations (4), (5), and (6) into equation (3) and rearranging yields a set of simultaneous equations (normalized equations) (7). Solving the set of equations (7) yields  $a_1$  to  $a_5$ .

$$\begin{aligned}
a_1 S_{11} + a_2 S_{12} + a_3 S_{13} + a_4 S_{14} + a_5 S_{15} &= S_{1C} \\
a_1 S_{21} + a_2 S_{22} + a_3 S_{23} + a_4 S_{24} + a_5 S_{25} &= S_{2C} \\
a_1 S_{31} + a_2 S_{32} + a_3 S_{33} + a_4 S_{34} + a_5 S_{35} &= S_{3C} \\
a_1 S_{41} + a_2 S_{42} + a_3 S_{43} + a_4 S_{44} + a_5 S_{45} &= S_{4C} \\
a_1 S_{51} + a_2 S_{52} + a_3 S_{53} + a_4 S_{54} + a_5 S_{55} &= S_{5C} \quad (7)
\end{aligned}$$

[0075] Constant term  $a_0$  is obtained by means of equation (4). The thus obtained  $a_i$  ( $i=0, 1, 2, 3, 4, 5$ ) is stored in

## EP 1 518 494 A1

ROM at the time of manufacture of the apparatus. In actual measurement using the apparatus, the normalized parameters  $X_1$  to  $X_5$  obtained from the measured values are substituted into regression equation (1) to calculate the glucose concentration  $C$ .

**[0076]** Hereafter, an example of the process of calculating parameter  $X_i$  will be described. The example concerns measurement values obtained from a physically unimpaired person. Coefficients for the parameter calculation equations are determined by temperature data and optical measurement data that have been measured in advance. The ROM in the microprocessor stores the following formula for the calculation of the parameter:

$$x_1 = 0.98 \times 10^{-3} \times (T_3)^4$$

$$x_2 = -1.24 \times (T_4 - T_3)$$

$$x_3 = 1.36 \times ([Hb] + [HbO_2])$$

$$x_4 = 2.67 \times \left( \frac{[HbO_2]}{[Hb] + [HbO_2]} \right)$$

$$x_5 = 1.52 \times 10^6 \times \left( \frac{1}{t_{CONT} \times (S_1 - S_2)} \right)$$

**[0077]** When  $T_3=36.5^\circ\text{C}$  is substituted in the above equations as a measurement value, for example,  $x_1=1.74 \times 10^3$ . When  $T_4=19.7^\circ\text{C}$  is substituted in the above equations,  $x_2=2.08 \times 10$ . Then, before finding  $x_3$ , it is necessary to find  $[Hb]$  and  $[HbO_2]$ . The coefficients for the concentration calculation formula are determined by the scattered-light absorbance coefficient of each substance that has been measured in advance. Using that equation,  $[Hb]$  and  $[HbO_2]$  can be determined by solving the following set of simultaneous equations in the case of measurement using two wavelengths:

$$A_{D2\_810} = 1.86 = 0.87\{800 \times [Hb] + 1050 \times [HbO_2]\} \times 1.04 \times 0.85$$

$$A_{D2\_950} = 2.02 = 0.87\{750 \times [Hb] + 1150 \times [HbO_2]\} \times 1.04 \times 0.85$$

$$a_R = 0.85 = \frac{1.35 \times (1.67 + 1.98)}{(2.65 + 3.14)}$$

$$D = 1.04 = \frac{1}{\frac{0.95 \times [1.02 + 1.01]}{2}}$$

**[0078]** Solving this set of simultaneous equations gives  $[Hb]=0.17$  mmol/L and  $[HbO_2]=2.17$  mmol/L. Thus we have  $x_3=3.18$  and  $x_4=2.48$ . Then, substituting  $S_1=1.76 \times 10^2$ ,  $S_2=1.89 \times 10$ , and  $t_{CONT}=22$  seconds gives  $x_5=4.40 \times 10^2$ .

**[0079]** The hemoglobin concentration  $([Hb] + [HbO_2])$  was calculated to be 2.34 mmol/L. When the hemoglobin concentration was measured at the same time by an invasive method, i.e. by blood sampling, the value was 2.28 mmol/L.

**[0080]** On the other hand, regarding the above measurement using two wavelengths to determine  $[Hb]$  and  $[HbO_2]$ , when the traveled photon is not detected by the light-receiving optical fiber 35 at the same time, the information about the thickness of the skin would not be obtained. In that case, the below-indicated simultaneous equations would be obtained, and solving them would yield  $[Hb] = 0.18$  mmol/L and  $[HbO_2] = 2.26$  mmol/L. Thus, the hemoglobin concentration  $([Hb] + [HbO_2])$  would be 2.44 mmol/L.

## EP 1 518 494 A1

$$A_{D2\_810} = 1.86 = 0.87\{800 \times [Hb] + 1050 \times [HbO_2]\} \times 0.85$$

$$A_{D2\_950} = 2.02 = 0.87\{750 \times [Hb] + 1150 \times [HbO_2]\} \times 0.85$$

$$a_R = 0.85 = \frac{1.35 \times (1.67 + 1.98)}{(2.65 + 3.14)}$$

[0081] Thus, it has been confirmed that the result of calculation in the case where traveled photon is detected by the light-receiving optical fiber 35 is closer to the value of hemoglobin concentration measured by blood sampling than the calculation result in the case where traveled photon is not detected by the light-receiving optical fiber 35. Thus, it has been shown that the measurement accuracy can be improved by providing the optical sensor portion 18 with the light-receiving optical fiber 35.

[0082] Next,  $X_1$  to  $X_5$  are obtained.  $X_1$  to  $X_5$  are the results of normalization of the above-obtained parameters  $x_1$  to  $x_5$ . Assuming the distribution of the parameters is normal, 95% of the normalized parameter takes on values between -2 and +2. The normalized parameters can be determined by the following equations:

$$X_1 = -0.06 = \frac{1.74 \times 10^3 - 1.75 \times 10^3}{167}$$

$$X_2 = 0.04 = \frac{2.08 \times 10 - 2.06 \times 10}{5}$$

$$X_3 = 0.05 = \frac{3.18 - 3.15}{0.60}$$

$$X_4 = -0.12 = \frac{2.48 - 2.54}{0.50}$$

$$X_5 = 0.10 = \frac{4.40 \times 10^2 - 4.28 \times 10^2}{120}$$

[0083] From the above equations, we have normalized parameters  $X_1=-0.06$ ,  $X_2=+0.04$ ,  $X_3=+0.05$ ,  $X_4=-0.12$ , and  $X_5=+0.10$ .

[0084] Hereafter, an example of the process of calculating the glucose concentration will be described. The coefficients in regression equation (1) are determined in advance based on many items of data obtained from able-bodied persons and diabetics, and the ROM in the microprocessor stores the following formula for calculating the glucose concentration:

$$C = 99.1 + 18.3 \times X_1 - 20.2 \times X_2 - 24.4 \times X_3 - 21.8 \times X_4 - 25.9 \times X_5$$

[0085] Substituting  $X_1$  to  $X_5$  gives  $C=96$  mg/dl. In the case of a diabetic patient, substituting exemplary measurement values in the equation such that  $X_1=+1.15$ ,  $X_2=-1.02$ ,  $X_3=-0.83$ ,  $X_4=-0.91$ , and  $X_5=-1.24$  yields  $C=213$  mg/dl.

[0086] Hereafter, the results of measurement by the conventional enzymatic electrode method and those by the method of the invention will be compared. In the enzymatic electrode method, a blood sample is reacted with a reagent and the amount of resultant electrons is measured to determine glucose concentration. When the glucose concentration for an able-bodied person was 89 mg/dl according to the enzymatic electrode method, the normalized parameters obtained by measurement at the same time according to the invention were  $X_1=-0.06$ ,  $X_2=+0.04$ ,  $X_3=+0.07$ ,  $X_4=-0.10$ , and  $X_5=+0.10$ . Substituting these values into the above equation yields  $C=95$  mg/dl. On the other hand, when the glucose concentration for a diabetic patient was 238 mg/dl according to the enzymatic electrode method, the normalized parameters obtained by measurement at the same time according to the invention were  $X_1=+1.15$ ,  $X_2=-1.02$ ,  $X_3=-0.86$ ,  $X_4=-1.02$ , and  $X_5=-1.24$ . Substituting these values into the above equation yields  $C=216$  mg/dl. The results thus indicated that the method according to the invention can provide highly accurate glucose concentration.

[0087] Fig. 14 shows the plot of glucose concentration for a plurality of patients. The calculated values of glucose

## EP 1 518 494 A1

concentration according to the invention are shown on the vertical axis, and the measured values of glucose concentration according to the enzymatic electrode method are shown on the horizontal axis. It will be seen that a good correlation can be obtained by measuring the oxygen supply volume and the blood flow volume according to the method of the invention (correlation coefficient=0.9394).

[0088] Thus, the invention can provide a highly accurate non-invasive blood sugar level measuring apparatus and method.

## Claims

## 1. An optical measurement apparatus comprising:

a first light source for producing light of a first wavelength that is irradiated onto a light incident point on the surface of an examined subject;

a second light source for producing light of a second wavelength that is irradiated onto said light incident point on the surface of said subject from a direction different from that of the light of said first wavelength;

a first photodetector on which reflected light of the light of said first wavelength reflected by said light incident point and scattered light of the light of said second wavelength are incident;

a second photodetector for receiving reflected light of the light of said second wavelength reflected by said light incident point and scattered light of the light of said first wavelength; and

a third detector for receiving light leaving a region on the surface of said subject that is away from said light incident point.

## 2. An optical measurement apparatus comprising a first light source for producing light of a first wavelength, a second light source for producing light of a second wavelength, a first photodetector, a second photodetector and a third photodetector, wherein

said first and second light sources emit light in a time-divided manner such that a light incident point on the surface of an examined subject is irradiated with the light of said first wavelength and the light of said second wavelength in a time-divided manner,

mainly reflected light of the light of said first wavelength is incident on said first photodetector from said light incident point when said first light source is emitting, while mainly scattered light of the light of said second wavelength is incident thereon when said second light source is emitting,

mainly reflected light of the light of said second wavelength is incident on said second photodetector from said light incident point when said second light source is emitting, while mainly scattered light of the light of said first wavelength is incident thereon when said first light source is emitting, and

said third photodetector is adapted to receive light that leaves a region on the surface of said subject which is away from said light incident point.

## 3. A blood sugar level measuring apparatus comprising:

(1) a heat amount measuring portion for measuring a plurality of temperatures derived from the body surface in order to obtain information that is used in calculating the amount of convective heat transfer and the amount of radiation heat transfer related to the dissipation of heat from the body surface;

(2) a blood flow volume measuring portion for obtaining information concerning the volume of blood flow;

(3) an optical measuring portion for obtaining the hemoglobin concentration and hemoglobin oxygen saturation in blood, said portion including a light source for generating light of at least two different wavelengths, an optical system for irradiating the body surface with light emitted by said light source, and at least three different photodetectors for detecting the light that has been shone on the body surface;

(4) a storage portion for storing the relationships between individual parameters corresponding to the multiple temperatures, blood flow volume, hemoglobin concentration and hemoglobin oxygen saturation in blood, and blood sugar levels;

(5) a computing portion for converting the measurement values provided by said heat amount measuring portion, said blood flow volume measuring portion, and said optical measuring portion into the aforementioned parameters, and computing a blood sugar level by applying said parameters to said relationships stored in said storage portion; and

(6) a display portion for displaying the blood sugar level computed by said computing portion, wherein

said optical measuring portion includes a first light source producing light of a first wavelength and emitting

## EP 1 518 494 A1

the light on a light incident point on the subject surface, a second light source producing light of a second wavelength and emitting the light on said light incident point on the subject surface from a direction different from that of the light of said first wavelength, a first photodetector, a second photodetector, and a third photodetector, wherein reflected light of the light of said first wavelength reflected by said light incident point and scattered light of the light of said second wavelength are incident on said first photodetector; reflected light of the light of said second wavelength reflected by said light incident point and scattered light of the light of said first wavelength are incident on said second photodetector; and said third photodetector is adapted to detect light that leaves a region on the subject surface that is away from said light incident point.

4. The apparatus of claim 3, wherein said optical measuring portion further comprises a control portion for controlling the emission of light from said first and second light sources, wherein said control portion causes said first and second light sources to emit light alternately, such that the light incident point on the subject surface is irradiated with the light of said first wavelength and the light of said second wavelength alternately, mainly reflected light of the light of said first wavelength is incident on said first photodetector from said light incident point when said first light source is emitting, while mainly scattered light of the light of said second wavelength is incident thereon when said second light source is emitting, mainly reflected light of the light of said second wavelength is incident on said second photodetector from said light incident point when said second light source is emitting, while mainly scattered light of the light of said first wavelength is incident thereon when said first light source is emitting.
5. The apparatus of any preceding claim, wherein the plane of incidence of the light of said first wavelength on said light incident point on the subject surface is substantially perpendicular to the plane of incidence of the light of said second wavelength.
6. The apparatus of claim 3, wherein the outgoing light from said first light source is irradiated onto said light incident point via a first optical fiber, the outgoing light from said second light source is irradiated onto said light incident point via a second optical fiber, the light incident on said first photodetector is incident on said first photodetector via a third optical fiber, and the light incident on said second photodetector is incident on said second photodetector via a fourth optical fiber.
7. The apparatus of claim 6, wherein the outgoing end of said first optical fiber, the outgoing end of said second optical fiber, the incident end of said third optical fiber and the incident end of said fourth optical fiber are disposed near the plane of a cone whose apex corresponds to said light incident point on the subject surface.
8. The apparatus of claim 6, further comprising a fifth optical fiber for transmitting the light leaving said region on the subject surface away from said light incident point to said third detector, wherein the incident end of said fifth optical fiber is disposed at a position in contact with the subject surface.
9. The apparatus of claim 8, wherein the distance between said light incident point on the subject surface and the incident end of said fifth optical fiber is larger than the distance between said light incident point and the incident end of said third optical fiber or the incident end of said fourth optical fiber.
10. The apparatus of claim 9, wherein the incident end of said fifth optical fiber is disposed on the plane of incidence of the light of said first wavelength or that of the light of said second wavelength.
11. The apparatus of claim 9, wherein the incident end of said fifth optical fiber is disposed on a plane that makes an angle of approximately 45° with the plane of incidence of the light of said first wavelength or that of the light of said second wavelength.
12. The apparatus of claim 6, wherein the first wavelength is a wavelength at which the molar absorption coefficient of oxyhemoglobin is equal to that of deoxyhemoglobin, and said second wavelength is a wavelength for detecting the difference in absorbance between the oxyhemoglobin and deoxyhemoglobin.
13. The apparatus of claim 12, wherein measurement error due to the thickness of the skin is corrected using the intensity of light measured by said third detector.

**EP 1 518 494 A1**

- 14.** The apparatus of claim 6, wherein a branch optical fiber is connected to said first and/or second optical fiber, wherein a light source is disposed at the end of said branch optical fiber for producing light of a wavelength different from those of said first and second light sources.

5

10

15

20

25

30

35

40

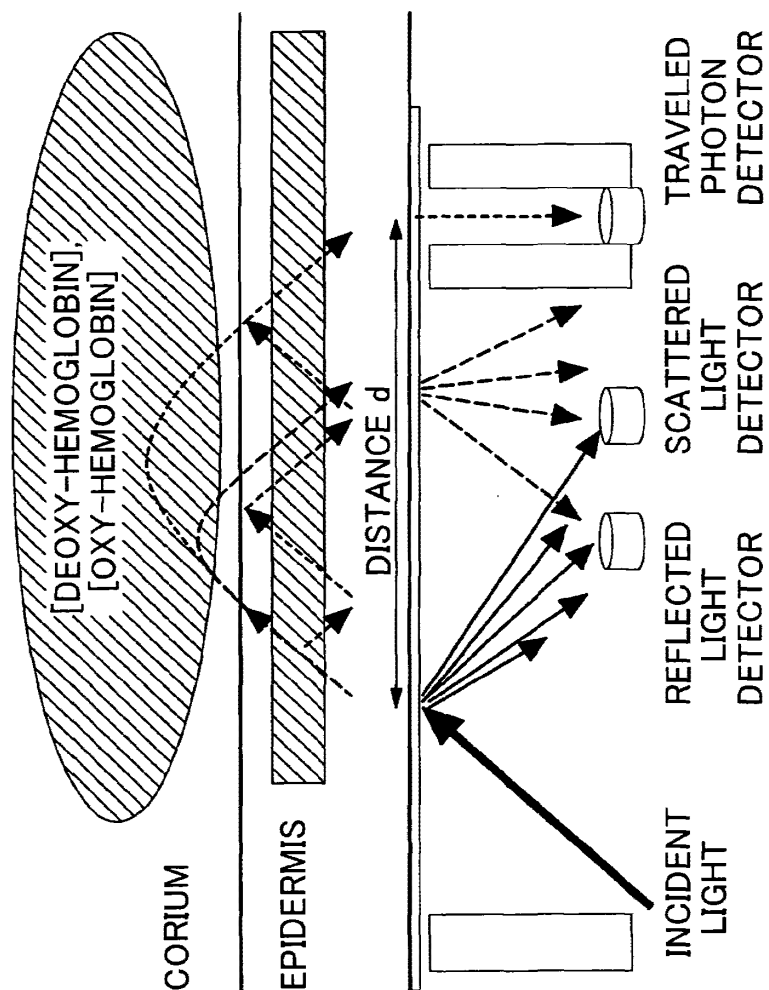
45

50

55



FIG.1



EP 1 518 494 A1

FIG.2

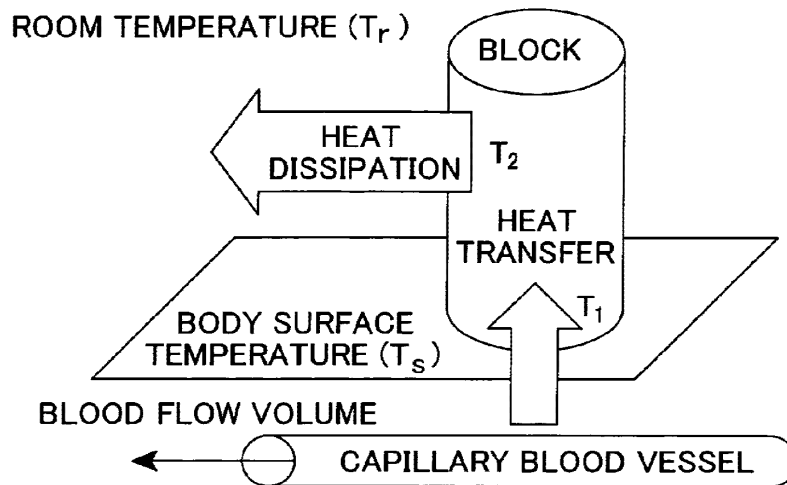
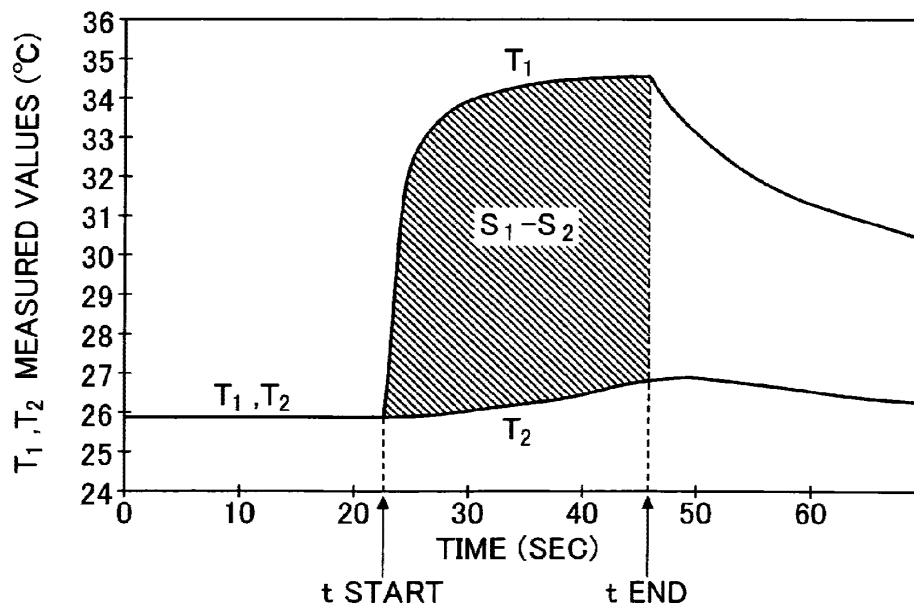


FIG.3



EP 1 518 494 A1

FIG.4

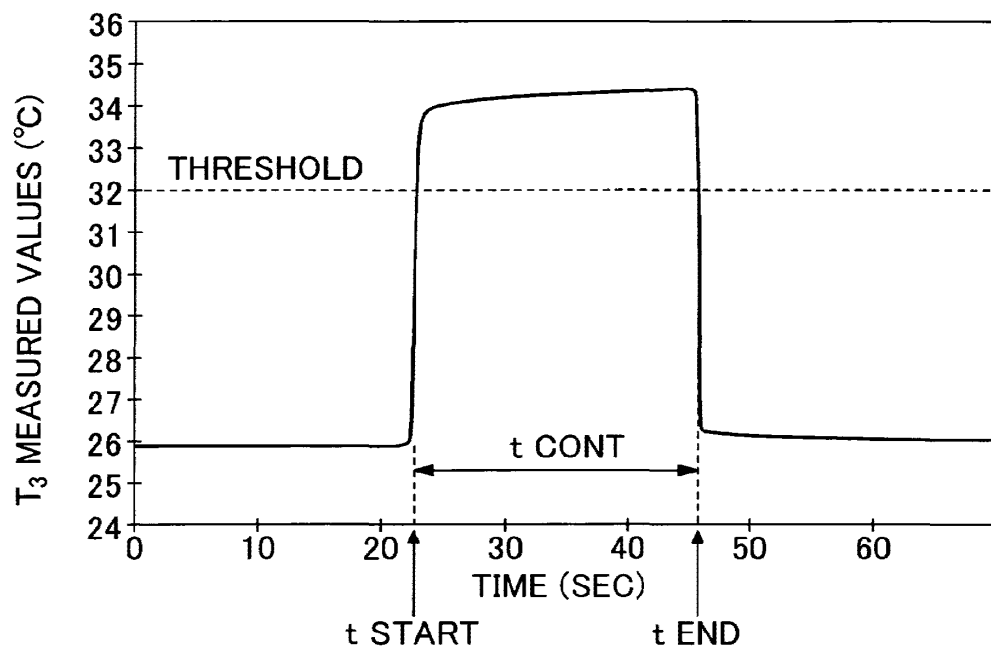
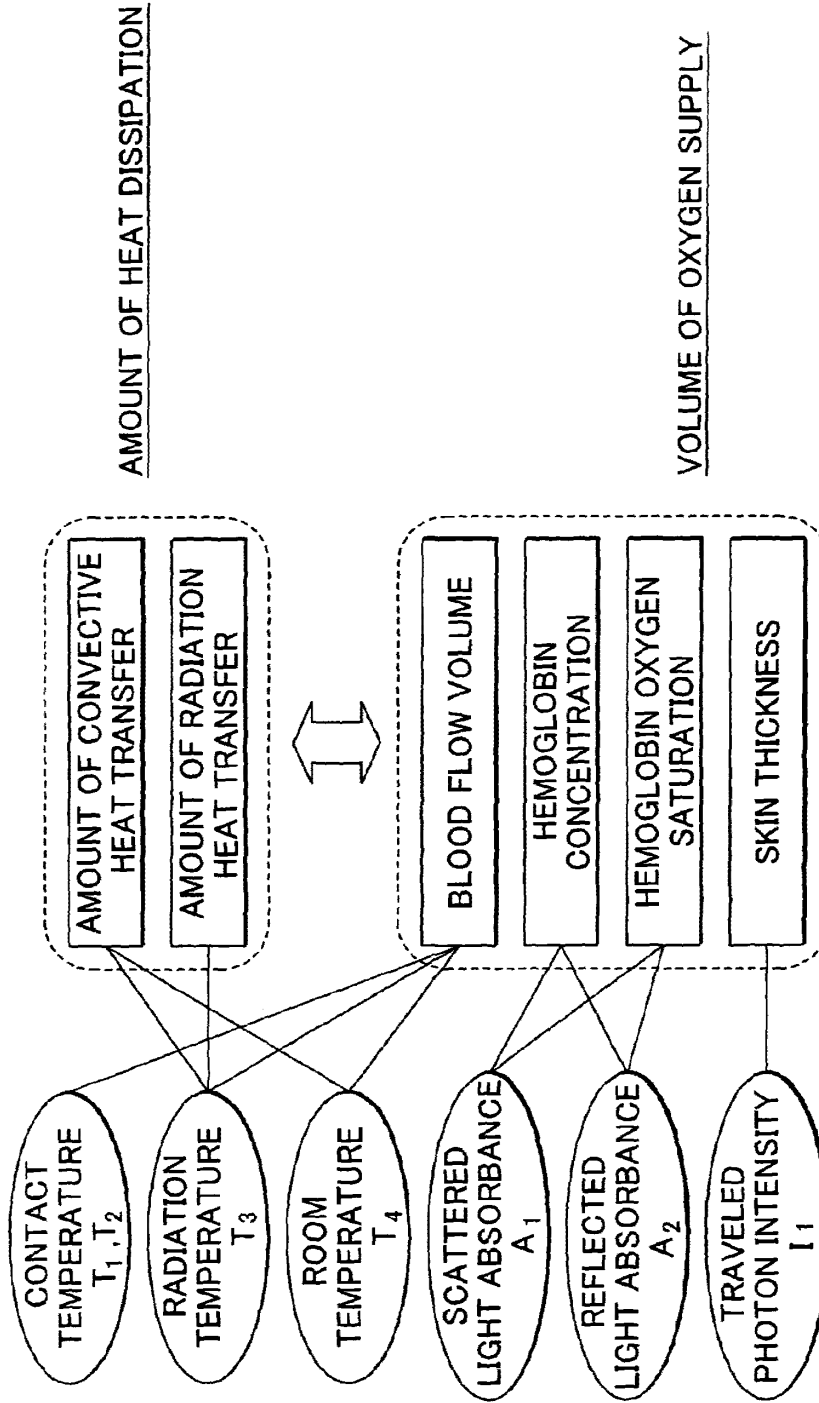
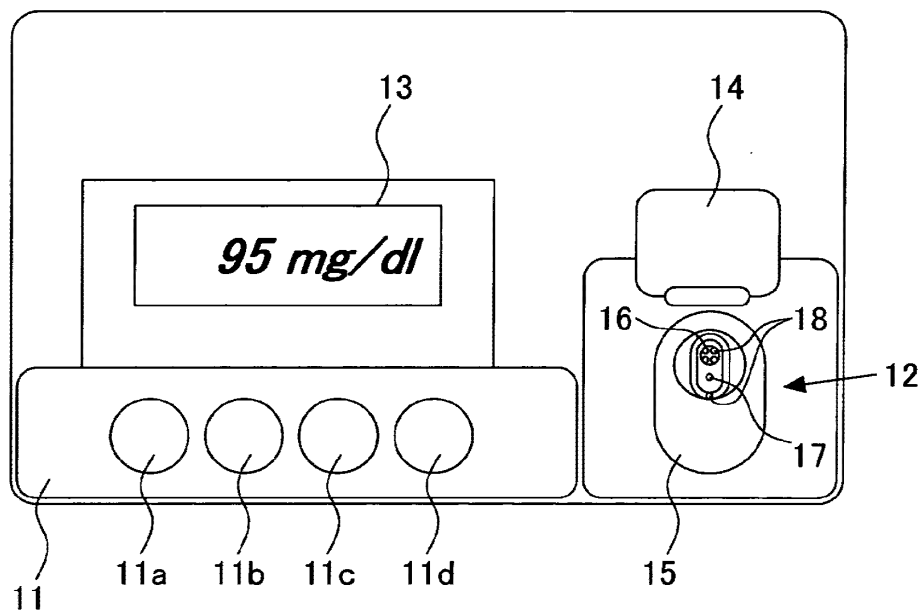


FIG.5



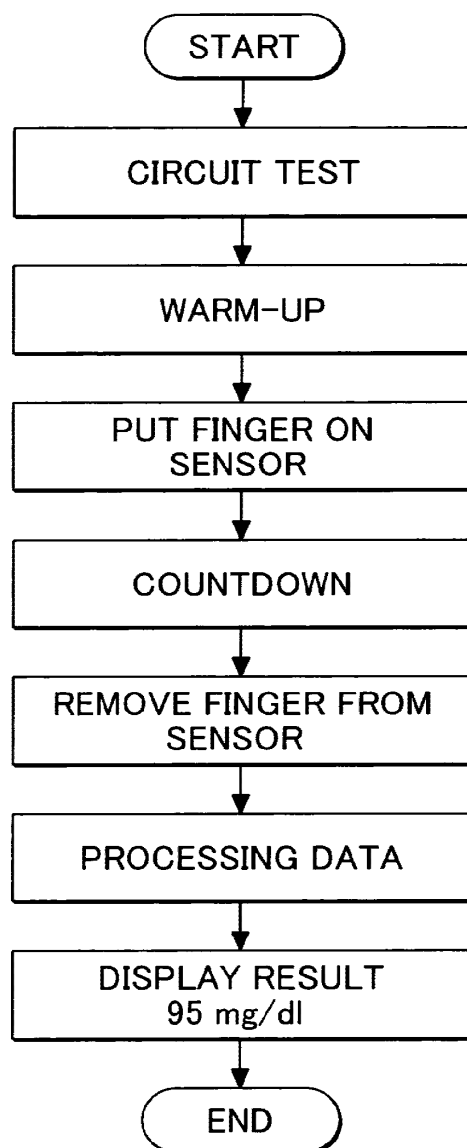
EP 1 518 494 A1

FIG.6



EP 1 518 494 A1

FIG. 7



EP 1 518 494 A1

FIG.8A

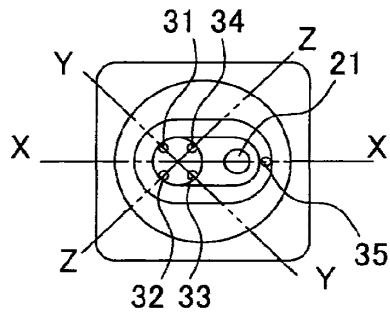


FIG.8B

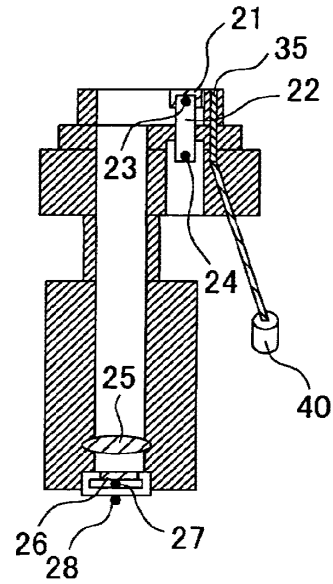


FIG.8C

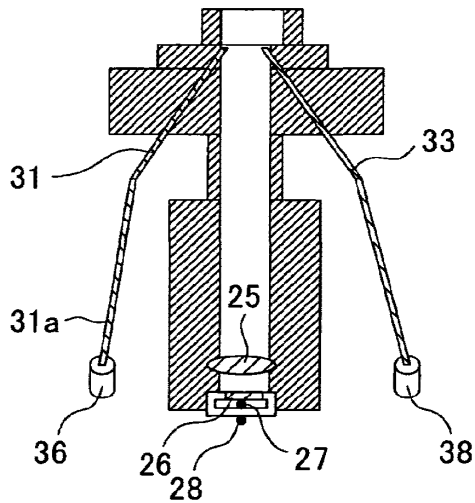
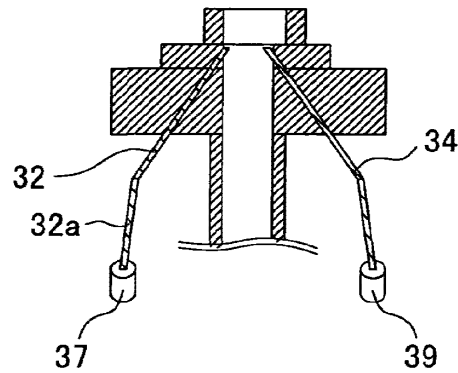


FIG.8D



EP 1 518 494 A1

FIG.8E

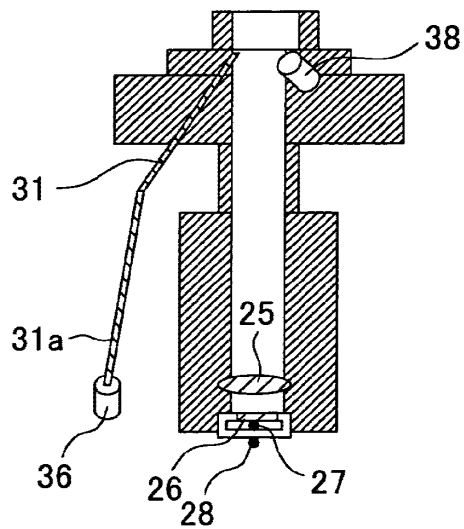


FIG.8F

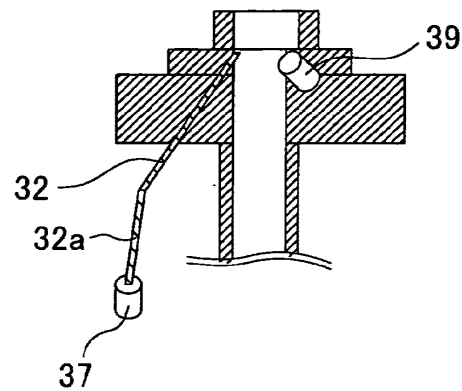


FIG.8G

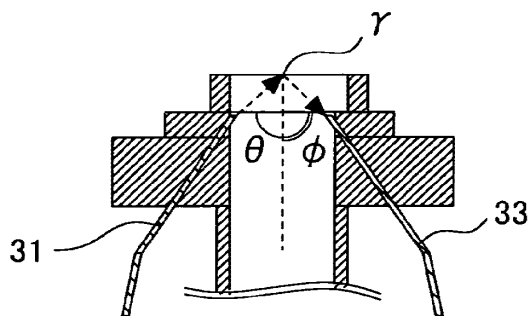
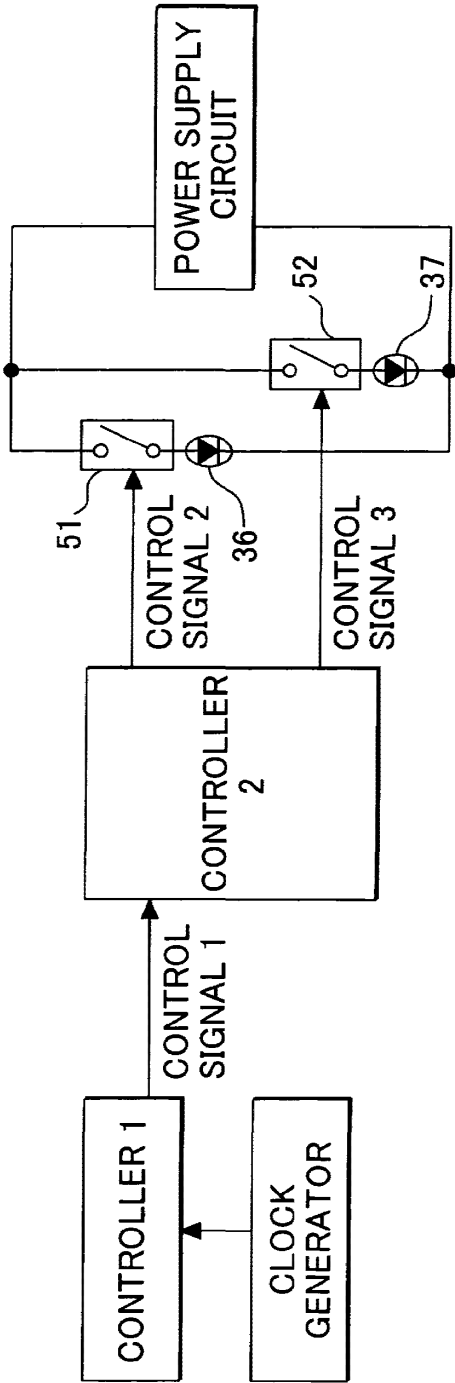




FIG.9



EP 1 518 494 A1

FIG.10A

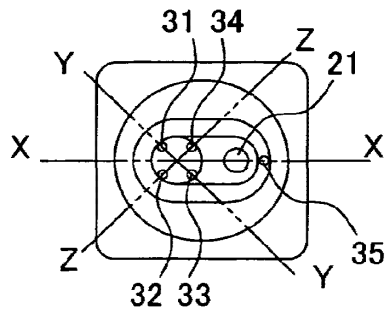


FIG.10B

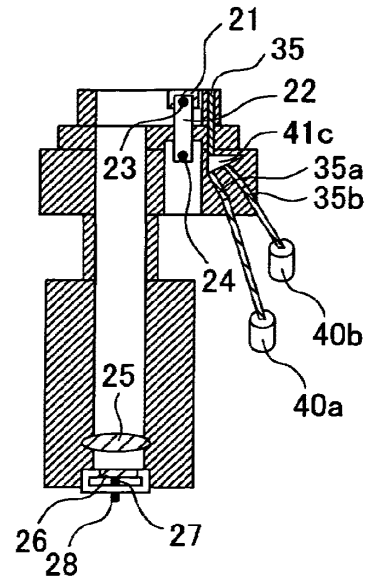


FIG.10C

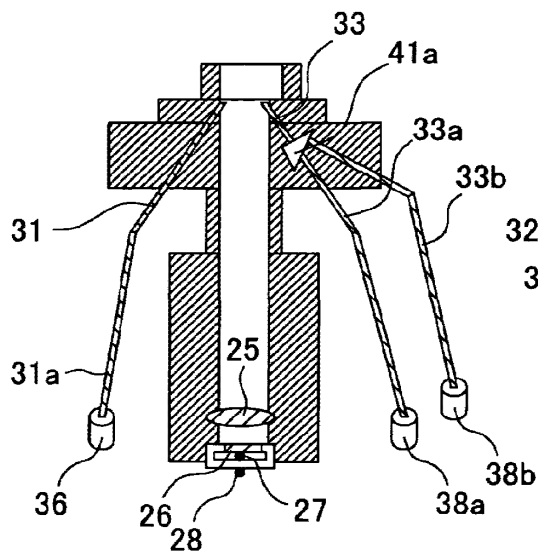
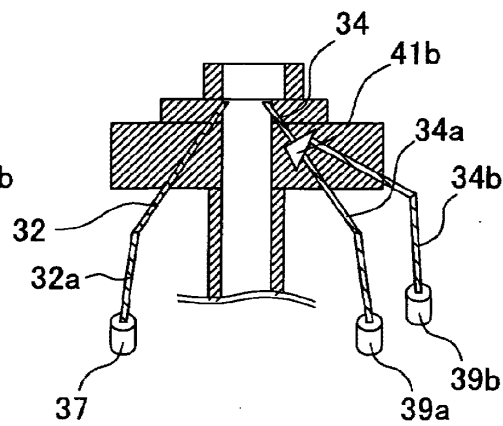


FIG.10D



EP 1 518 494 A1

FIG.11A

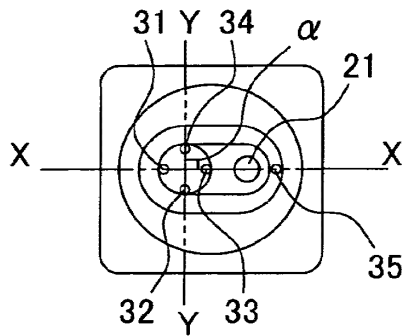


FIG.11B

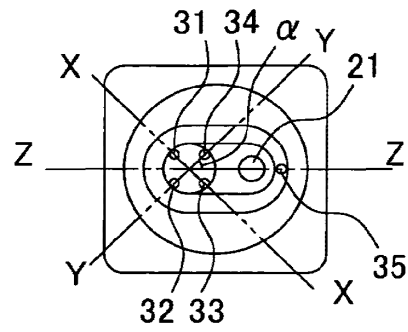


FIG.11C

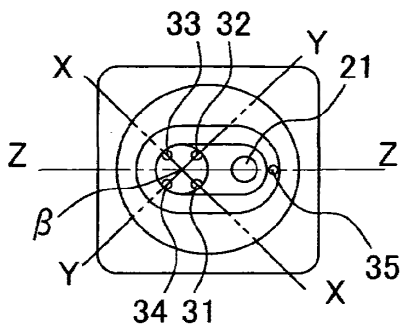
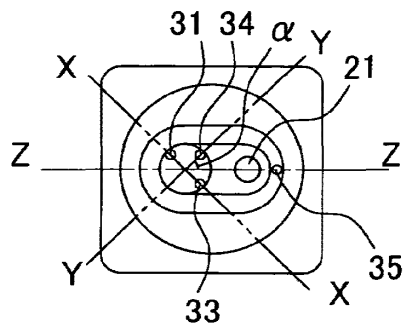


FIG.11D



EP 1 518 494 A1

FIG.11E

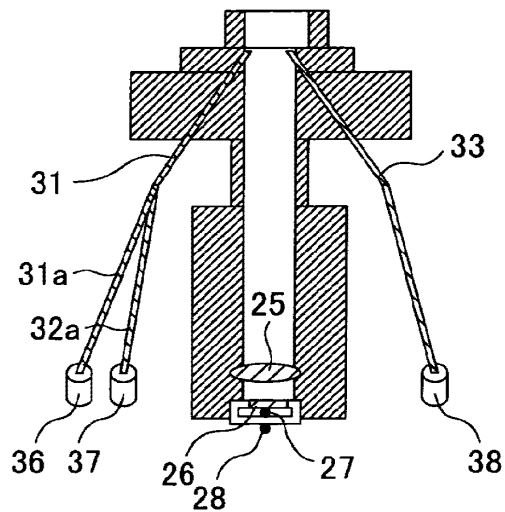


FIG.11F

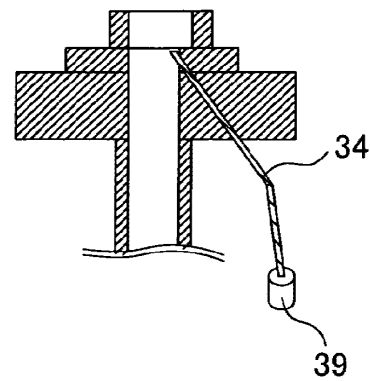
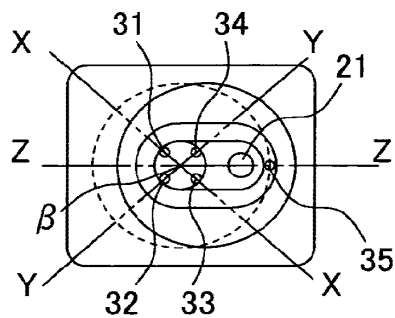


FIG.11G



EP 1 518 494 A1

FIG.12A

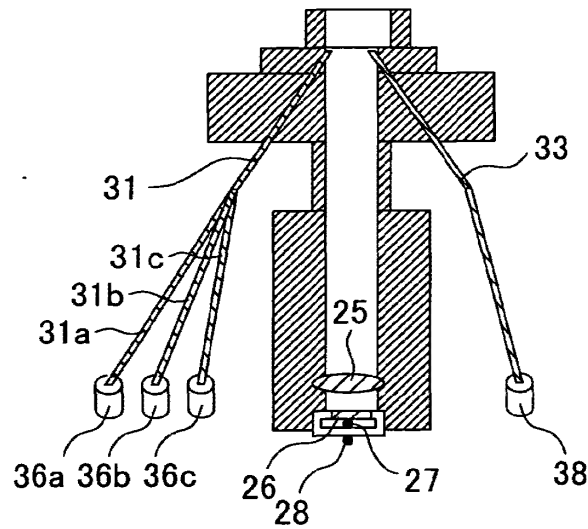
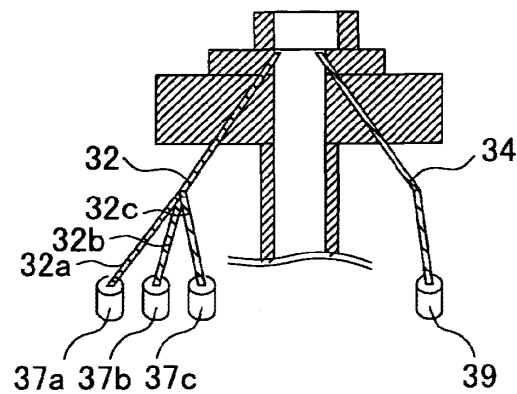
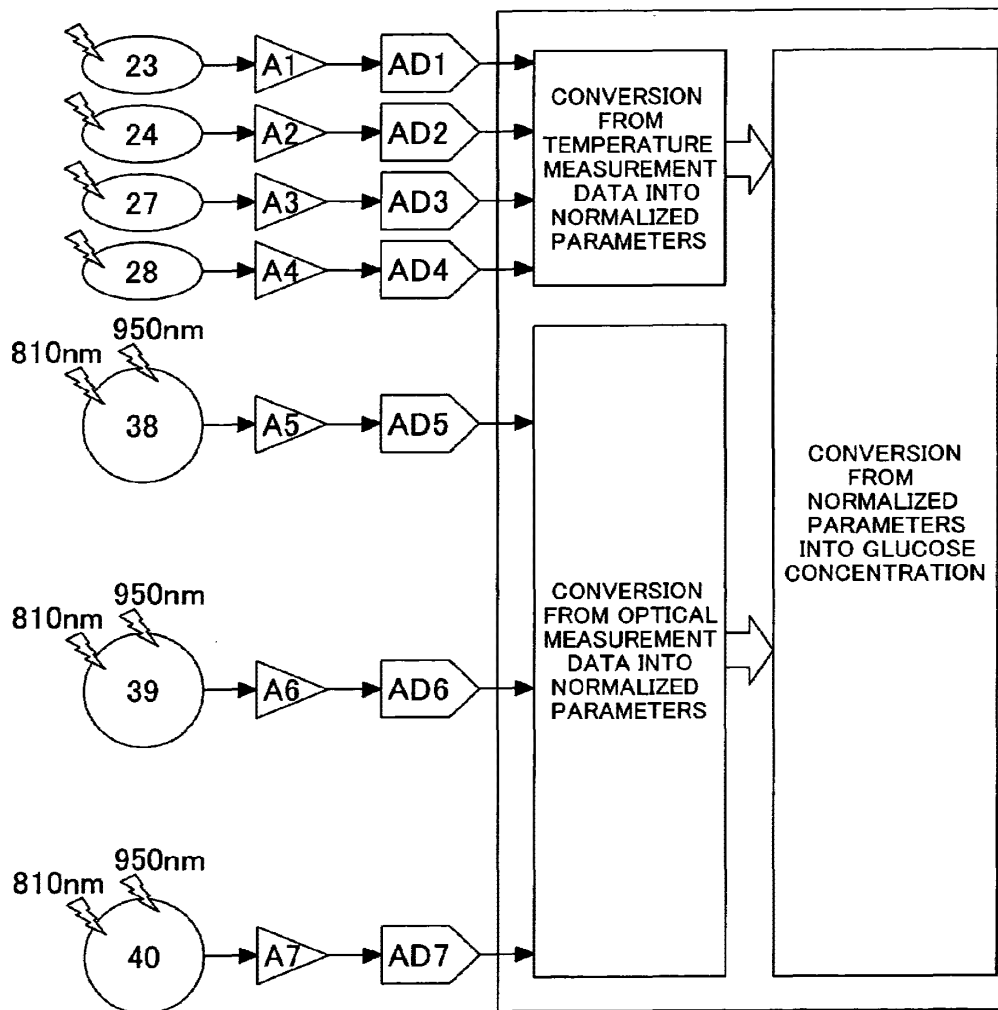


FIG.12B



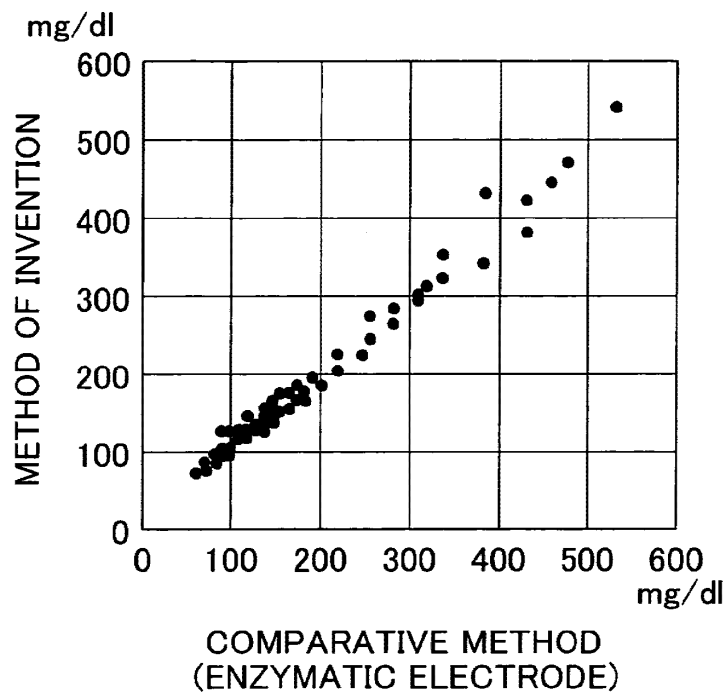
EP 1 518 494 A1

FIG.13



EP 1 518 494 A1

FIG.14



EP 1 518 494 A1

European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 04 00 1845

## DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	WO 01/28414 A (CHO OK KYUNG ; KAUFMANN KIM YUN OAK (DE)) 26 April 2001 (2001-04-26) * page 8, lines 6-10 * * page 11, lines 16-26 * * page 12, lines 11-25 * * page 15, line 25 - page 16, line 33 * * page 17, line 32 - page 18, line 4 * -----	3,12	A61B5/00 A61B5/103 G01N21/47
Y	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 13, 30 November 1999 (1999-11-30) - & JP 11 230901 A (SHIMADZU CORP), 27 August 1999 (1999-08-27) * abstract * * paragraphs [0034], [0045]; figure 9 * -----	1,2	
Y	US 4 750 140 A (AIZAWA HITOSHI ET AL) 7 June 1988 (1988-06-07) * column 3, lines 14-32; figure 3 * * column 6, lines 12-45 * -----	1,2	
A	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 06, 31 July 1995 (1995-07-31) - & JP 07 071945 A (KAO CORP; others: 01), 17 March 1995 (1995-03-17) * abstract * * paragraphs [0010] - [0015]; figures 2-4 * -----	1,2,5	TECHNICAL FIELDS SEARCHED (Int.Cl.7)  A61B G01N
The present search report has been drawn up for all claims			
Place of search Berlin		Date of completion of the search 29 September 2004	Examiner Kronberger, R
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03 02 (P04C01)



EP 1 518 494 A1

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 00 1845

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-09-2004

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 0128414	A	26-04-2001	WO 0128414 A2	26-04-2001
JP 11230901	A	27-08-1999	NONE	
US 4750140	A	07-06-1988	JP 1642183 C	28-02-1992
			JP 3007897 B	04-02-1991
			JP 61130857 A	18-06-1986
			JP 1596675 C	27-12-1990
			JP 2024458 B	29-05-1990
			JP 61130858 A	18-06-1986
			JP 1591790 C	30-11-1990
			JP 2019420 B	01-05-1990
			JP 62126331 A	08-06-1987
			CA 1240052 A1	02-08-1988
			DE 3579119 D1	13-09-1990
			EP 0183270 A2	04-06-1986
JP 07071945	A	17-03-1995	NONE	

EPO FORM P0159

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

## (12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau(43) International Publication Date  
8 February 2001 (08.02.2001)

PCT

(10) International Publication Number  
**WO 01/09589 A1**(51) International Patent Classification<sup>7</sup>: **G01N 21/49**,  
21/31, A61B 5/0060048 (US). **KANTOR**, Stanislaw; 485 Satinwood Terrace, Buffalo Grove, IL 60089 (US). **JENG**, Tzyy-Wen; 311 Appleton Drive, Vernon Hills, IL 60061 (US).

(21) International Application Number: PCT/US00/20730

(22) International Filing Date: 28 July 2000 (28.07.2000)

(74) Agents: **WEINSTEIN**, David, L. et al.; Dept. 377, AP6D-2, 100 Abbott Park Road, Abbott Park, IL 60064-6050 (US).

(25) Filing Language: English

(81) Designated States (*national*): CA, JP.

(26) Publication Language: English

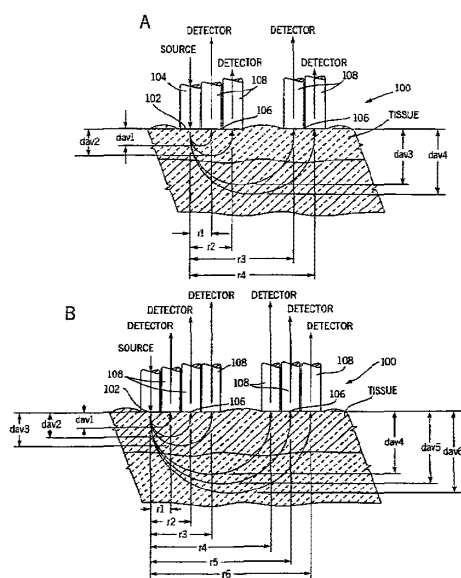
(30) Priority Data:  
09/366,084 3 August 1999 (03.08.1999) US(84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).(71) Applicant: **ABBOTT LABORATORIES** [US/US];  
Dept. 377/ AP6D-2, 100 Abbott Park Road, Abbott Park,  
IL 60064-6050 (US).**Published:**

- With international search report.
- Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.

(72) Inventors: **KHALIL**, Omar, S.; 1506 Portwine Court, Libertyville, IL 60048 (US). **WU**, Xiaomao; 17188 West Gurnee Glen, Gurnee, IL 60031 (US). **YEH**, Shu-jen; 920 Stratford Court, Grayslake, IL 60030 (US). **HANNA**, Charles, F.; 410 West Lincoln Avenue, Libertyville, IL

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: OPTICAL SENSOR HAVING A SELECTABLE SAMPLING DISTANCE FOR DETERMINATION OF ANALYTES



(57) **Abstract:** A method and apparatus for the measurement of trans-cutaneous diffuse reflectance at a single sampling distance for determining the concentration of an analyte in a biological sample, such as, for example, human tissue. The determination of the concentration of the analyte has been found to depend on the sampling distance and reaches an optimal result at a defined sampling distance for a given analyte and a given sample. The method involves measuring the light re-emitted from the sample at a distance from a light introduction site and correlating the intensity of the re-emitted light to the concentration of an analyte. For a given sample, the distance between the light collection site and a light introduction site (i.e., the sampling distance) corresponds to the depth from the surface into the sample at which scattering and absorption events significantly affect the intensity of re-emitted light (i.e., the sampling depth). Prior knowledge about the sample determines the optimal sampling depth for performing a measurement for a specific analyte and the corresponding sampling distance needed to reach that optimal sampling depth. Optimization of the sampling distance, as well as the correlation relationship, can be established in a calibration procedure.

WO 01/09589 A1

WO 01/09589

PCT/US00/20730

1

**OPTICAL SENSOR HAVING A SELECTABLE SAMPLING DISTANCE FOR  
DETERMINATION OF ANALYTES**

5

**BACKGROUND OF THE INVENTION**

This application is a continuation-in-part of U. S. Serial No. 09/198,049, filed  
10 November 23, 1998.

**1. Field of the Invention**

This invention relates to devices and methods for the determination of the  
15 concentration of an analyte in a human tissue. More specifically, this invention  
relates to devices and methods for the non-invasive determination of the  
concentration of one or more analytes in vivo in a human tissue, wherein an optical  
property at a given depth in the tissue is significantly affected by a given analyte.

**2. Discussion of the Art**

Non-invasive monitoring of analytes in the human body by optical devices and  
methods is an important tool for clinical diagnosis. "Non-invasive" (alternatively  
referred to herein as "NI") monitoring techniques measure in vivo concentrations of  
25 analytes in the blood without taking out a blood sample from the human body. As  
defined herein, a "non-invasive" technique is one that can be used without removing  
a sample from, or without inserting any instrumentation into, the human body. The  
ability to determine an analyte, or a disease state, in a human subject without  
performing an invasive procedure, such as removing a sample of blood or a biopsy  
30 specimen, has several advantages. These advantages include ease in performing  
the test, reduced pain and discomfort to the patient, and decreased exposure to  
potential biohazards. These advantages will promote increased frequency of testing,  
accurate monitoring and control of a disease condition, and improved patient care.

WO 01/09589

PCT/US00/20730

2

Representative examples of non-invasive monitoring techniques include pulse oximetry for oxygen saturation (U. S. Patent Nos. 3,638,640; 4,223,680; 5,007,423; 5,277,181; 5,297,548). Another example is the use of laser Doppler flowmetry for diagnosis of circulation disorders (Tooke et al, "Skin microvascular blood flow control  
5 in long duration diabetics with and without complication", Diabetes Research, Vol. 5, 1987, pages 189-192). Other examples of NI techniques include determination of tissue oxygenation (WO 92/20273), determination of hemoglobin (U. S. Patent No. 5,720,284), and hematocrit (U. S. Patent Nos. 5,553,615; 5,372,136; 5,499,627; WO 93/13706). Determination of bilirubin was also described in the art (R. E.  
10 Schumacher, "Noninvasive measurement of bilirubin in the newborn", Clinics in Perinatology, Volume 17, 1990, pages 417-435, and U. S. Patent No. 5,353,790).

Measurements in the near-infrared region of the electromagnetic spectrum have been proposed, or used, in the prior art. The 600 nm to 1300 nm region of the electromagnetic spectrum represents a window between the visible hemoglobin and  
15 melanin absorption bands and the strong infrared water absorption bands. Light having a wavelength of 600 nm to 1300 nm can penetrate sufficiently deep into the skin to allow use thereof in a spectral measurement or a therapeutic procedure.

Oximetry measurement is very important for critical patient care, especially after the use of anesthesia. Oxygenation measurements of tissue are also important  
20 diagnostic tools for measuring oxygen content of the brain of the newborn during and after delivery, for monitoring tissue healing, and in sports medicine.

Non-invasive determination of hemoglobin and hematocrit values in blood would offer a simple, non-biohazardous, painless procedure for use in blood donation centers. Such techniques could increase the number of donations by  
25 offering an alternative to an invasive procedure, which is inaccurate and may possibly lead to the rejection of a number of qualified donors. Non-invasive determination of hemoglobin and hematocrit values would be useful for the diagnosis of anemia in infants and mothers, without the pain associated with blood sampling. Non-invasive determination of hemoglobin has been considered as a method for  
30 localizing tumors and diagnosis of hematoma and internal bleeding (S. Gopinath, et al., "Near-infrared spectroscopic localization of intracamerial hematomas", J. Neurosurgery, Vol. 79, 1993, pages 43-47). Non-invasive determination of hematocrit values can yield important diagnostic information on patients with kidney

WO 01/09589

PCT/US00/20730

3

failure before and during dialysis (R. R. Steuer, et al., "A new optical technique for monitoring hematocrit and circulating blood volume; Its application in renal dialysis", Dialysis and Transplantation, Volume 22, 1993, pages 260-265). There are more than 50 million dialysis procedures performed in the United States and close to 80 million dialysis procedures performed world-wide annually.

Non-invasive diagnosis and monitoring of diabetes may be the most important potential advantage for non-invasive diagnostics. Diabetes mellitus is a chronic disorder of carbohydrate, fat, and protein metabolism characterized by an absolute or relative insulin deficiency, hyperglycemia, and glycosuria. At least two major variants of the disease have been identified. "Type I" accounts for about 10% of diabetics and is characterized by a severe insulin deficiency resulting from a loss of insulin-secreting beta cells in the pancreas. The remainder of diabetic patients suffer from "Type II", which is characterized by an impaired insulin response in the peripheral tissues (Robbins, S. L. et al., Pathologic Basis of Disease, 3rd Edition, W. B. Saunders Company, Philadelphia, 1984, p. 972). If uncontrolled, diabetes can result in a variety of adverse clinical manifestations, including retinopathy, atherosclerosis, microangiopathy, nephropathy, and neuropathy. In its advanced stages, diabetes can cause blindness, coma, and ultimately death.

The concept upon which most NI detection procedures are based involves irradiating a tissue or a vascular region of the body with electromagnetic radiation and measuring the spectral information that results from at least one of three primary processes: absorption, scattering, and emission. The extent to which each of these processes occurs is dependent upon a variety of factors, including the wavelength of the incident radiation and the concentration of analytes in the body part. Signals are measured as a change in reflectance or transmittance of the body part.

Concentration of an analyte, e. g., glucose, hemoglobin or bilirubin is determined from the spectral information by comparing the measured spectra to a calibration data set. Alternatively the concentration of an analyte is determined by comparing the magnitude of the change in signal to the results of calculations based on a physical model describing the optical properties of the tissue under examination. Various categories of non-invasive measurement techniques will now be described.

NI techniques that utilize the interaction of a sample with infrared radiation can be categorized according to three distinct wavelength regions of the

WO 01/09589

PCT/US00/20730

4

electromagnetic spectrum: near-infrared (NIR), mid-infrared (MIR) and far-infrared (FIR). As defined herein, NIR involves the wavelength range from about 600 nm to about 1300 nm, MIR involves the wavelength range from about 1300 nm to about 3000 nm, and FIR involves the wavelength range from about 3000 nm to about 25000 nm. As defined herein, "infrared" (or IR) is taken to mean a range of wavelengths from about 600 nm to about 25000 nm.

Due to the highly scattering and absorption nature of the human skin and tissue, light in the 600 nm to 1300 nm spectral range penetrates the skin and underlying tissues to different depths. The tissue depth at which most of the reflectance signal is generated (sampling depth) depends on the wavelength of light and positioning of the source and detector. Analyzing the reflected or transmitted signal without accounting for the effect of different layers of skin can lead to erroneous estimates of the optical properties of the tissue and hence, the concentration of metabolites determined from these measured properties. The stratum corneum, epidermis, dermis, adipose tissue, and muscle layers can interact with light differently and contribute separately to the measured signals. Controlling the sampling depth of the light and understanding the effect of the different layers of the skin on the generated signal are important for the accurate non-invasive determination of metabolites in tissues. The NIR spectral region has been used for determination of blood oxygen saturation, bilirubin, hemoglobin, hematocrit, and tissue fat content. It is also used for exciting and detecting therapeutic agents in photodynamic therapy. At longer wavelengths in MIR region, water absorption bands are dominant in tissue spectra. There are some narrower spectral windows in the 1500 nm to 1900 nm range and the 2100 nm to 2500 nm range, where both in vitro and in vivo tissue measurements have been performed.

Light striking a tissue will undergo absorption and scattering. Most of the scattered photons are elastically scattered, i. e., they keep the same frequency as the incident radiation (e.g., Rayleigh scattering). A small fraction of the scattered light (less than one in a thousand incident photons) is inelastically scattered (Raman scattering). Unless otherwise indicated herein, "scattering" refers to elastic scattering.

Because of the multiple scattering effect of tissue, optical measurements of either transmission or reflectance will contain tissue scattering information, as well as

WO 01/09589

PCT/US00/20730

5

absorption information. Tissue scattering information includes cell size and cell shape, depth of the tissue layer in which scattering occurs, and refractive index of intracellular fluids and extracellular fluid (interstitial fluid). Absorption information includes absorption by tissue components, such as hemoglobin, melanin, and bilirubin, and the overtone absorption of water, glucose, lipids, and other metabolites.

One method for measuring elastic light scattering of tissues and turbid media is spatially resolved diffuse reflectance (SRDR), where detection fibers are placed at multiple distances from a light entry point. Reflectance values at different distances from the illumination point are used to calculate the absorption and scattering coefficients of the tissue based on photon diffusion theory models or numerical calculations such as Monte Carlo simulations. The values of the absorption and scattering coefficients are then used to correlate with the concentration of an analyte.

As shown in FIG. 1, light is introduced into the surface of a tissue sample, such as a body part, at an introduction site. The diffusely reflected light is measured at two or more detection sites located on the surface of the sample (e.g., the skin) at different distances,  $r$ , from the introduction site. The dependence of the intensity of the diffusely reflected light, i. e., reflectance  $R$ , as a function of the distance between the detector and the light source in touch with the sample ( $r$ ) is used to derive scattering and absorption coefficients of the tissue sample. These coefficients, in turn, are correlated with the concentration of analyte(s) (see, for example, U. S. Patent No. 5,492,118).

European Patent No. 0843986A2 describes a reflectance spectrophotometer for blood glucose measurement from human skin. The spectrophotometer intends to minimize the influence of undesirable spectral information from the epidermis by separating the light introduction site and the light detection site. This undesirable spectral information is in the form of diffuse surface reflectance that depends on the condition of the surface of the skin. In the arrangement disclosed therein, however, light penetrates through the epidermis twice - once at the light introduction site and once at the light detection site, and its properties will be affected by the optical properties of the epidermis. The method of European Patent No. 0843986A2 is based on the erroneous assumption that light penetrating to a lower layer of the skin will not be affected by the optical properties of the upper layers. The method does not account for both of the scattering and absorption properties of different skin

WO 01/09589

PCT/US00/20730

6

layers being affected by different tissue analytes and relies mainly on absorption of glucose in the 1300-2500 spectral range, which is dominated mainly by water absorption.

The above prior art methods do not address the effect of skin layers on signal, distribution of analytes in these layers, and the effect of each analyte on the optical properties of each layer.

The use of absorption and scattering coefficients derived from mathematical models that assume homogeneous non-layered structures can lead to inaccurate determination of analytes in tissue. Further, use of measurement methods that average out over several layers and multiple compartments of the skin or other samples can also lead to complicated and misrepresenting data.

An important variable in an in vivo measurement is the fluctuation of blood volume at the measurement site. Fluctuation in blood volume at the measurement site could result from such factors as lack of anatomical homogeneity, blood vessel dilation or constriction due to hormonal control, or change in ambient temperature. A change in the volume fraction of the blood can lead to erroneous measurement if the concentration of a non-absorbing analyte is calculated from scattering data as suggested by U. S. Patent No. 5,551,422 and U. S. Patent No. 5,492,118.

Scattering of red blood cells and the effect of blood volume on fluid contents of tissue affect the values of the scattering coefficients and hence the calculated concentration of analytes such as glucose determined in the near-IR (600-nm to 1300 nm). In the same manner, changes in scattering values of tissue affect the calculated values of the absorption coefficient and can affect the calculated concentrations of absorbing analytes, such as hemoglobin, bilirubin, and colored therapeutic agents.

Although a variety of techniques have been disclosed in the art, there is still no commercially available device that provides non-invasive glucose measurements with an accuracy that is comparable to the established invasive methods. Devices for non-invasive measurement of bilirubin and hematocrit have been commercialized. However, signals obtained by prior art methods operate on the assumption that the tissue comprises a single uniform layer. As the change in optical signal due to a weakly absorbing analyte such as glucose is expected to be



WO 01/09589

PCT/US00/20730

7

small, any approximation in the over-simplified skin model or in the calculation of the scattering and absorption coefficients will lead to erroneous results. The signals, for example, are vulnerable to the effects of top layers of the skin, which are significantly different from the deeper layers of the skin in terms of textures, colors, and other properties.

Thus, there is a continuing need for improved NI instruments and methods that are unaffected by variations in skin structures and layers or account for the effect of skin layers. There is also a need for instruments with simple calibration schemes that can be set in the factory and periodically checked for accuracy in the field.

Co-pending U. S. Application Serial No. 09/198,049, filed November 23, 1998 ("Non-invasive sensor capable of determining optical parameters in a sample having multiple layers"), assigned to the assignee of this application, describes methods for determining optical properties of tissue with multiple layers. The methods involve the use of multiple groups of closely spaced optical fibers that are located at spatially resolved measurement sites. Each group yields information on a specific layer in the sample that is determined by the distance between the light illumination site and the residing site of the group. The layers described in the co-pending application are within the depth of 3 mm for human tissue samples. In body parts with a thin skin such as the forearm or the abdomen, this depth encompasses the stratum corneum, the epidermis and the dermis layers.

Skin components affect its optical properties in different ways depending if they are strongly absorbing, such as hemoglobin, bilirubin and melanin, or strongly scattering such as cells and muscle fibers. The color of the human skin is affected mostly by the contents of hemoglobin, melanin and bilirubin. Densities, sizes and shapes of cells and the refractive indexes of intercellular fluids (interstitial fluid) and intracellular fluid will affect skin scattering, especially in the relatively uniform epidermis and upper dermis. Analytes that may cause changes in the cell sizes and shapes and the refractive indexes of fluids can be tracked by measuring the scattering coefficient of these layers. Compounds that may have significant effect on these changes in the interstitial fluid are glucose, salts, proteins, fatty acids, and water. However, as light gets deeper into the dermis it starts to probe capillary beds

WO 01/09589

PCT/US00/20730

8

and upper and lower plexus. Further deeper in the subcutaneous tissues, light interacts with capillaries, veins, various corpuscles, adipose tissues, etc.

### **SUMMARY OF THE INVENTION**

5

We have discovered that the measurement of trans-cutaneous diffuse reflectance at a single sampling distance can achieve good correlation with the concentration of an analyte in a biological sample, such as, for example, human tissue. Such correlation has been found to depend on the sampling distance and reaches an optimal result at a defined sampling distance for a given analyte and a given biological sample.

10

This invention provides a method for determining the concentration of an analyte in a biological sample, typically one having a plurality of layers, e. g., a sample of human tissue. The method comprises the steps of:

15

(a) introducing a beam of light into the biological sample at a light introduction site on a surface of the biological sample;

(b) collecting the light re-emitted from the biological sample at a light collection site on the surface of the biological sample, the light collection site located at a distance from the light introduction site, the distance of the light collection site from the light introduction site corresponding to a sampling depth in the biological sample, at which sampling depth an optical property of the biological sample is significantly affected by the analyte;

20

(c) determining the intensity of the collected light; and

25

(d) determining the concentration of the analyte from the intensity of the collected light.

The method involves measuring the light re-emitted at a distance from the light introduction site and correlating the intensity of the re-emitted light to the concentration of an analyte. For a given biological sample, the distance between the light collection site and a light introduction site (i. e., sampling distance) corresponds

30

WO 01/09589

PCT/US00/20730

9

to the depth from the surface into the biological sample at which scattering and absorption events significantly affect the intensity of re-emitted light (i. e., sampling depth). Prior knowledge about the biological sample determines the optimal sampling depth for performing a measurement for a specific analyte and the corresponding sampling distance needed to reach that optimal sampling depth. Optimization of the sampling distance, as well as the correlation relationship, can be established in a calibration procedure described herein.

In a preferred embodiment of this invention, a method for determining the concentrations of a plurality of analytes in a biological sample, typically one having a plurality of layers, e. g., a sample of human tissue, comprises the steps of:

(a) introducing a beam of light into the biological sample at a light introduction site on a surface of the biological sample;

(b) collecting the light re-emitted from the biological sample at a light collection site on the surface of the biological sample, the light collection site located at a distance from the light introduction site, the distance of the light collection site from the light introduction site corresponding to a sampling depth in the biological sample, at which depth an optical property of the biological sample is significantly affected by one analyte of the plurality of analytes;

(c) determining the intensity of the collected light;

(d) determining the concentration of the one analyte of the plurality of analytes from the intensity of the collected light; and

(e) repeating steps (a), (b), (c), and (d) for at least another analyte of the plurality of analytes.

The method of this invention is applicable for an arrangement wherein a single light introduction site and one or more light collection sites are employed. The method of this invention is also applicable for an arrangement wherein a single light collection site and one or more light introduction sites are employed. In either variation, the method is capable of determining the concentration of at least one component of a sample of human tissue having a plurality of layers, wherein each of these layers has different properties that are affected differently by the concentration of analytes in the tissue.

WO 01/09589

PCT/US00/20730

10

Another aspect of this invention involves a method whereby the selection of the sampling distance at which each analyte is determined is accomplished automatically by means of a programmable device. At the time of measurement, the sampling distance and the wavelength(s) of the incident light are selected by a computer, based on an input that includes the specific analyte to be determined and the prior knowledge about the sample.

In another aspect, this invention provides an apparatus for determining the concentration of at least one analyte in a biological sample, typically one having a plurality of layers, e. g., a sample of human tissue. The apparatus comprises:

(a) a means for introducing a beam of light into the biological sample at a light introduction site on a surface of the biological sample;

(b) a means for collecting light re-emitted from the biological sample at at least one light collection site on the surface, the at least one light collection site located at a predetermined sampling distance from the light introduction site, the predetermined sampling distance corresponding to a sampling depth, at which sampling depth an optical property of the biological sample is significantly affected by the analyte;

(c) a means for determining the intensity of the light collected at each light collection site; and

(d) a means for determining the concentration of the at least one analyte from the intensity of the light collected at one of the light collection sites.

In an alternative of this apparatus, the apparatus comprises:

(a) a means for introducing a beam of light into the biological sample at at least one light introduction site on a surface of the biological sample;

(b) a means for collecting the light re-emitted from the biological sample at a light collection site on the surface, the at least one light introduction site being located at a predetermined distance, as measured on the surface, from the light collection site, each predetermined distance corresponding to a predetermined sampling depth in the biological sample;

WO 01/09589

PCT/US00/20730

11

(c) a means for determining the intensity of the light collected at the light collection site; and

(d) a means for determining the concentration of at least one analyte from the intensity of the light collected at the light collection site.

5

In another aspect, a non-stationary illumination and detection system can be used and the sampling distance can be selected by moving a single illuminating element on the skin surface via a mechanism similar to a compact disk (CD) player read head. With a single light collecting element fixed at a given light collection site, the illuminating element can be moved to a predetermined position and thereby illuminate a site on the skin surface that is at a desired distance from the light collection site. Mechanisms for directing a light beam to predetermined sampling distances include beam steering devices such as moving mirrors or prisms. Alternatively, a system can comprise a stationary illuminating element and a movable light collection element.

10

15

This invention provides the following advantages over techniques that use a spatially resolved diffuse reflectance measurement (U. S. Patent Nos. 5,075,695; 5,492,118; and 5,551,422):

(1) This invention accounts for the effect of the layers of tissue samples on the measurement.

20

(2) Selection of sampling distance, and , hence sampling depth, allows collection of optimal analyte signal relative to interfering signal for each analyte and each individual.

(3) This invention incorporates both absorption and scattering information and allocates appropriate balance between both types of information to maximize the effectiveness of analyte determination.

25

(4) In the normal mode of operation of this invention, signal detection relies on measurement at only one sampling distance, thereby simplifying the instrumentation.

(5) The method of this invention directly correlates the intensity of light collected to the concentration of an analyte and consequently eliminates the need for an algorithm for handling results based on assumptions such as the diffusion theory approximation or the complex Monte Carlo modeling computation. This invention

30

WO 01/09589

PCT/US00/20730

12

also eliminates the errors associated with the conversion of reflectance values to scattering and absorption coefficients through empirical or semi-empirical algorithms.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

5

FIG. 1 is a schematic diagram illustrating (1) an arrangement of light collection sites with respect to the light introduction site and (2) the sampling depth,  $d$ , for a given sampling distance,  $r$ .

FIG. 2 is a diagram illustrating the layers of tissues in the skin.

10

FIG. 3 is a block diagram illustrating a device of this invention.

FIG. 4A is a diagram illustrating a bifurcated optical fiber bundle.

FIG. 4B is a series of diagrams showing portions of the bifurcated optical fiber bundle of FIG. 4A.

15

FIG. 5 is a diagram illustrating the nominal separation distances,  $r$ , between light collection sites and the light introduction site.

FIG. 6 is an illustration of the correlation coefficient and standard error of calibration for the non-invasive determination of hematocrit as a function of sampling distance.

20

FIG. 7 is a calibration diagram for hematocrit measurement. The sampling distance was 1.84 mm.

FIG. 8 is a calibration diagram for glucose measurement in a meal tolerance test. The sampling distance was 0.92 mm.

FIG. 9 is a Clark error grid presentation of calibration results in glucose measurement. The sampling distance was 0.92 mm.

25

### **DETAILED DESCRIPTION**

As used herein, "biological sample" includes, but is not limited to, a sample of intact or excised human tissue, such as, for example, a sample of intact or excised human skin, a human body part. Due to biological activities, the concentrations of components of a given biological sample may change over time. Repeated in vivo measurements of the biological sample may be required to monitor such changes.

WO 01/09589

PCT/US00/20730

13

The expression "tissue optics" refers to the study of light propagation in biological tissues. The expression "optical properties" refers to the absorption, scattering, emission, and depolarization properties of the tissues. The expression "optical parameter" refers to a parameter that describes and defines an optical property of a medium and its components. Examples of optical parameters include absorption coefficients, scattering coefficients, anisotropy factors, transport optical mean free path, extinction coefficients of analytes. The expression "scattering media" refers to media that both scatter light and absorb light. The expression "absorption coefficient" (i.e.,  $\mu_a$ ) refers to the probability of light absorption per unit path length. The expression "scattering coefficient" (i.e.,  $\mu_s$ ) refers to the probability of light scattering per unit path length. The expression "anisotropy factor" (i.e.,  $g$ ) refers to the average cosine of the scattering angle for a multiply scattered photon. The expression "reduced scattering coefficient" (i.e.,  $\mu_s'$ ) refers to the probability of equivalently isotropic (uniform in all directions) scattering per unit path length. The reduced scattering coefficient is related to the scattering coefficient  $\mu_s$  and the anisotropy factor  $g$  by the relationship  $\mu_s' = (1-g) \mu_s$ . The expression "penetration depth" (i.e.,  $\delta$ ) refers to the rate of decay of light intensity in scattering media with respect to the path traveled by the light in the same direction as the incident light. Penetration depth  $\delta$  is the reciprocal of the effective attenuation coefficient  $\mu_{\text{eff}}$ , i.e.,  $\delta = 1/\mu_{\text{eff}}$ .

The expression "Monte Carlo simulation" refers to a numerical method that can be used to statistically describe photon propagation in scattering media. The expression "diffuse reflectance" (reflectance therein unless specified otherwise) refers to measurement of light that is re-emitted from a sample at all angles different from the direction of the incident light, and over an area wider than the area where the incident light is introduced into the sample. The expressions "spatially resolved scattering" or "spatially resolved diffuse reflectance" refer to a measurement of light that is re-emitted from a sample and collected at several light collection sites at specific distances from a light introduction site. Alternatively, these expressions can refer to the light collected at a given light collection site on the sample boundary as a result of introducing light at discrete light introduction sites located on the same boundary at defined distances from the light collection site. In both instances,  $\mu_{\text{eff}}$ ,  $\mu_a$  and  $\mu_s'$  are calculated from the intensity distribution of the re-emitted light with

WO 01/09589

PCT/US00/20730

14

respect to distances, i.e., the re-emitted light intensity at a multiplicity of sampling distances. The expressions "re-emitted light" and "reflected light" are used synonymously herein, as are the expressions "reflectance" and the "intensity of re-emitted light", unless otherwise indicated. The expression "frequency domain measurement" refers to a measurement of light involving the phase angle and/or the amplitude change of modulated incident light, at a given separation distance of a light introduction site from a light collection site, as the light transverses a scattering medium. The expression "beam of light" refers to a group of photons traveling together in nearly parallel trajectories toward a sample and striking the surface of the sample in a predefined area only. As a practical matter, the predefined area on the surface of a sample struck by a given beam of light is that area that is covered by an illuminating element, such as an optical fiber. The expression "significantly affect" refers to a measurable effect on an optical property of a biological sample at a given depth in that biological sample resulting from a change in concentration of an analyte at that depth. For example, in a sample of human skin, a change in concentration of melanine significantly affects the absorption coefficient in the epidermis. As another example, a change in concentration of hemoglobin significantly affects the absorption coefficient in the dermis and a change in concentration of glucose significantly affects the scattering coefficient in the epidermis and the dermis.

The expression "light introduction site" means a location on the surface of a sample, e. g., a body part, tissue, or the like, at which light is injected or inserted into the sample. The source of the light can be located at the light introduction site or can be located remote from the light introduction site. If the source of light is located remote from the light introduction site, the light must be transmitted to the light introduction site by light transmitting means, such as, for example, optical fibers. The expression "illuminating element" means a component located at the light introduction site that delivers light to the sample, e. g., a body part, tissue, or the like. The illuminating element is typically an optical fiber that transmits light from a source of light to the light introduction site. However, if the source of light is located at the light introduction site, the source of light can be the illuminating element. The expression "light collection site" means a location on the surface of a sample, e. g., a body part, tissue, or the like, at which light that is re-emitted from the sample is collected for measurement. The detector, which determines the intensity of the re-



WO 01/09589

PCT/US00/20730

15

emitted light, can be located at the light collection site or can be located remote from the light collection site. If the detector is located remote from the light collection site, the light must be transmitted to the detector by light transmitting means, such as, for example, optical fibers. The expression "light collecting element" means a

5 component located at the light collection site that collects light that is re-emitted from the sample, e. g., a body part, tissue, or the like. The light collecting element is typically an optical fiber that transmits light from the light collection site to a detector. However, if the detector can be located at the light collection site, the detector can be the light collecting element. The distance between a light introduction site and a

10 light collection site, as measured along the surface of a sample, is defined as the "sampling distance". For a given sample, the sampling distance determines the mean depth from the surface of the sample into the interior of the sample from which the scattering and absorption events contribute to the measured re-emitted light. Such mean depth is hereinafter referred to as the "sampling depth", which is

15 dependent on the sampling distance.

A typical skin tissue of a human body is illustrated in FIG. 2 (Source: Dorland's Illustrated Medical Dictionary, 26<sup>th</sup> Ed., W. B. Saunders, Philadelphia, 1985, p. 1212). It is clearly shown that there are at least three identifiable layers of tissue in the skin, which are the epidermis, the dermis and subcutaneous tissue.

20 The epidermis is the outermost and nonvascular layer of the skin, varying in thickness from 70 to 120  $\mu\text{m}$ , except on the palms and soles where it may be as thick as 0.8 mm and 1.4 mm, respectively. The epidermis can be further divided into layers, primarily including the stratum corneum (on the outer surface), stratum granulosum, stratum spinosum, and stratum basale (in conjunction with dermis).

25 The dermis consists of a dense bed of vascular connecting tissue, typically varying in thickness from 1 to 2 mm. Although it contains venous plexus in both upper and lower layers, more adipose (i.e., fatty) tissues are found in the lower layer. Major veins are located in subcutaneous tissue.

The effect of samples and media on light will now be discussed briefly.

30 The color of the human skin is affected mostly by the contents of hemoglobin, melanin, and bilirubin, which are the major components in the skin that exhibit significant absorption in the visible and near IR regions of the electromagnetic spectrum. The reddish color of the skin depends to a great extent on the quantity of

WO 01/09589

PCT/US00/20730

16

blood in the subpapillary (upper layer of dermis) venous plexus. The black, yellow, or white skin colors of people originating from different races reflect to a great extent the melanin content located mainly in the lower layers of the epidermis. In the case of patients with cholestasis, an excess amount of bilirubin diglucuronide (a conjugated bilirubin) will appear in blood and tissue in the skin. Another important optical property of the skin is its scattering coefficient. In general, the critical factors that affect the skin's scattering coefficient are the densities, sizes, and shapes of the cells, and the refractive indexes of intercellular fluids and intracellular fluid. The expressions "intercellular fluid", "extracellular fluid", and "interstitial fluid" are used synonymously to mean the fluid in a biological sample that fills spaces between cells of tissues. The epidermis is relatively uniform (though having several layers), and so is the upper dermis, in horizontal directions parallel to the sampling surface (see FIG. 2). However, deeper and deeper into the dermis and subcutaneous tissues, the skin becomes less and less homogeneous as capillaries, veins, various corpuscles, adipose tissues, etc. appear. Then, the effects of refractive index, cell size, and cell shape on the scattering coefficient of the tissue become less important, as the macroscopic structures of the muscles and tissues become more pronounced. In the top layers (e.g., epidermis and upper dermis), the cell sizes and shapes and the refractive indexes of fluids have a significant effect on the scattering coefficient. Analytes that may cause changes in the cell sizes and shapes and the refractive indexes of fluids can be tracked by measuring the scattering coefficient of these layers. For example, any analyte exhibiting significant concentration changes in the intracellular or intercellular fluids can cause the refractive index to change in these fluids. Change in concentration of analytes in the extracellular fluid can also result in changes in the sizes and the shapes of the cells because of osmolality changes in and around the cells. Compounds that may significantly affect these changes in the skin are salts, proteins, fatty acids, sugars (mainly glucose), and water. Also, an increase of the density of cells in blood, i.e., hematocrit, will cause more scattering in the upper dermis layer.

Analytes can be categorized as chromophores, which are molecules that exhibit high absorption in the visible and near-IR spectral range, and non-chromophores, which are molecules that exhibit low absorption in the visible and near-IR spectral range. Chromophores can be determined by the measurement of

WO 01/09589

PCT/US00/20730

17

absorption coefficient. Diffusion theory requires that  $\mu_s' \gg \mu_a$  in order to assure a multiple scattering condition. Thus, in order to determine a chromophore such as hemoglobin value (or, in turn, hematocrit) only those near-IR wavelengths at which hemoglobin has low absorption must be used. The methods based on the diffusion theory require the use of long pathlength in tissue, which in turn requires a large sampling distance. Large sampling distances usually result in weak signals and poor signal-to-noise ratios.

Non-chromophores exhibit less absorption in visible and near-IR region of the spectrum but may significantly affect the refractive index, and hence, the scattering coefficient of the medium or a sample. Non-chromophores can be determined from the reflectance signal at sampling distances close to the light introduction site. Blood hemoglobin content and hematocrit can be determined from the capillary bed and upper and lower plexus by measuring the intensity of the reflected light at greater sampling distances. This re-emitted light mainly originates from a greater sampling depth, in contrast to the determination of analytes in the epidermis and the top layer of the dermis. Some other analytes that absorb light at short wavelengths in visible region of the spectrum. An example is bilirubin that absorbs at 460 nm. Light penetration depth at these wavelengths can be as shallow as 200  $\mu\text{m}$  to 250  $\mu\text{m}$ . Thus, signals detected from a light collection site at a sampling distance close to the light introduction site can be used for a correlation with the concentration of these analytes in the tissue. Therapeutic agents used in photodynamic therapy, such as porphyrin derivatives, absorb light at 600 to 900 nm and could be determined by the method of this invention.

At wavelengths in visible and near-IR region, scattering of the light dominates absorption of the light in biological tissues (i. e.,  $\mu_s' \gg \mu_a$ ), and photon propagation deviates significantly from Beer's law. One major reason for tissue to scatter light is the existence of mismatch between the indexes of refraction of either the extracellular fluid (ECF) or the intracellular fluid (ICF) and the cellular membranes of the tissue. As used herein, the expression "cellular membranes" encompasses both the cell membrane as well as the membranes of organelles, such as mitochondria or nuclei. Besides undergoing scattering and absorption inside the tissue, photons can be reflected at the tissue/air interface; photons can also be re-emitted from the tissue.

WO 01/09589

PCT/US00/20730

18

When tissue samples are irradiated at visible and near-infrared wavelengths of light, where the dimension (size) of the scattering material (particles such as cells) is close to the magnitude of the wavelength of light, the reduced scattering coefficient,  $\mu_s'$ , can be expressed using Mie theory as follows:

5

$$\mu_s' = 3.28\pi a^2 \rho (2\pi n_{ex} / \lambda)^{0.37} (m-1)^{2.09} \quad (1)$$

where,

$\rho$  represents the volume density, number of particles per unit volume;

10

$a$  represents the radius of the scattering particle (e. g., cells, mitochondria, or collagen fibrils);

$n_{ex}$  represents the refractive index of the medium (ECF or ICF);

$m = (n_{in}/n_{ex})$ , the ratio of the refractive index of the scattering particle  $n_{in}$  to the refractive index of the medium  $n_{ex}$ ; and

15

$\lambda$  represents the wavelength of the light.

See Graaff, et al., "Reduced light-scattering properties for mixtures of spherical particles: a simple approximation derived from Mie calculations", Applied Optics, Vol. 31, 1992, page 1.

20

For a given incident wavelength,  $\mu_s'$  changes directly with either the cell size, "a", or the refractive index ratio "m", as shown in Equation (1). Because the refractive index of the scattering particles,  $n_{in}$ , remains relatively constant,  $\mu_s'$  is influenced mostly by  $n_{ex}$  and particle radius "a". For example, an increase in concentration of glucose, or concentration of other solutes, reduces tissue scattering by decreasing the refractive index difference between the ECF and the cellular membranes. Variations in  $n_{ex}$  are not specific for a particular analyte, however, and are affected by any change in the total concentration of solutes in the ECF, including changes in the concentration of glucose, fatty acids, and proteins. The value of  $n_{ex}$  is also susceptible to changes in physiological variables, such as temperature and hydration state of the tissue.

30

WO 01/09589

PCT/US00/20730

19

Determination of  $\mu_a$ ,  $\mu_s$ , and  $g$  of a tissue at different wavelengths can give information on physical and chemical properties of the tissue, such as concentration of analytes, cell sizes, and tissue heterogeneity. Methods of determining  $\mu_{\text{eff}}$ ,  $\mu_s'$  and  $\mu_a$  are known in the art. One of these methods is the measurement of diffuse  
 5 reflectance of the skin tissue. In a diffuse reflectance measurement, the measured reflectance is a function of the reduced scattering coefficient  $\mu_s'$ , the absorption coefficient  $\mu_a$ , the refractive index of the scattering medium  $n_s$ , and the refractive index of the surrounding layer  $n_o$ , which is usually air.

One of the methods of measuring the absorption and scattering coefficients of  
 10 tissue is referred to as spatially resolved diffuse reflectance, wherein the intensity of re-emitted light is a function of the distance of the light introduction site from the light collection site on the detection surface. In this method, the intensity of the light re-emitted from a sample is measured at several distances on the surface from the site at which light is introduced into the sample. Under certain conditions, intensity of the  
 15 re-emitted light is related to the separation of the light introduction site from the light collection site by the relationship:

$$R(r) = K_o [\exp (-\mu_{\text{eff}}r)]/r \quad \text{or} \quad (2)$$

$$\text{Log}[r \bullet R(r)] = \text{Log}(K_o) - \mu_{\text{eff}}r \quad (3)$$

where,  $R(r)$  represents the intensity of light reflected from a sample at a light collection site, which is separated from the light introduction site by a distance  $r$ ,  $K_o$  is a constant,  $\mu_{\text{eff}}$  is the effective attenuation coefficient, and  $\text{Log}(K_o)$   
 25 represents the natural logarithm of a number  $K_o$ .

Separation of  $\mu_{\text{eff}}$  into absorption and scattering coefficient usually introduces errors in the estimation because of the assumptions used and the statistical nature of the above approach. Thus, quantitation errors of 5% and up to 10% can be encountered  
 30 in the determination of  $\mu_s$  and  $\mu_a$  (M. Patterson, et al., "Reflectance as a function of distance, Calculated absorption coefficients and concentrations of PDT dyes in vivo", SPIE Proceedings, Vol. 1065, 1989, pages 115-122, and J. T. Bruulsema, et al.

WO 01/09589

PCT/US00/20730

20

“Correlation between blood glucose concentration in diabetics and non-invasively measured tissue optical scattering coefficients”, Optics Letters, Vol. 22, 1997, pages 190-192). If the absorption coefficient of a tissue sample does not fall within the values used in the model assumptions, this approach will lead to erroneous values of the scattering coefficient. These erroneous values may lead to erroneous estimates of the concentrations of analytes determined on the basis of the effect of concentrations on the refractive index of the tissue, and hence the scattering coefficient of the tissue.

The ability to determine  $\mu_s'$  and  $\mu_a$  separately and accurately depends on the use of diffusion theory approximation and requires a certain ratio of the scattering coefficient to the absorption coefficient ( $\mu_s' \gg \mu_a$ ). This requirement limits the wavelength range of the measurement to wavelengths where this relationship holds. Diffusion theory also requires a large separation between the source and the detector, and hence large bodies mass such as skull, the biceps or the calves (U. S. Patent No. 5,492,118). Diffusion theory is also based on the assumption that human tissue is a homogeneous medium. The structure of the skin is known in the art. Several layers are distinguishable, i.e., the epidermis (including the stratum corneum), the dermis, and subcutaneous tissue. The greater the separation between the source and the detector, the greater the probability of encountering heterogeneous sub-structures such as major blood vessels, muscle fibers and fat tissue.

One way to avoid the limitations of the diffusion theory approximation involves the use of numerical methods, such as the Monte Carlo calculation, to determine the scattering and absorption coefficients,  $\mu_s'$  and  $\mu_a$ . The accuracy of the determined values depends on the inputs to the model, and accounting for layers of skin in such a model is difficult.

The present invention involves methods and apparatus for the measurement of optical properties of tissue taken across a skin boundary, while accounting for the effects of skin layers on the properties measured. The measurement of optical properties of tissue across a skin boundary is adversely affected by the non-homogeneity of the different layers of the skin. Prior art methods and devices ignore the effect of multiple layers of skin tissue on the measured optical properties. Thus, U. S. Patent Nos. 5,057,695; 5,551,422; 5,676,143; 5,492,118; 5,419,321;

WO 01/09589

PCT/US00/20730

21

5,632,273; and 5,513,642 are silent as to the effect of different layers of skin on optical measurements, and they disclose no methods or apparatus that address this issue. Other prior art methods use widely separated sources of light and detectors of light and a diffusion theory approach to map deep tissue layers. These methods  
 5 operate on large body masses, such as the skull, thigh, or large arm muscles. Studies of blood circulation in skin show that cutaneous microcirculation occurs at depths of 1 to 2 mm below the skin's epidermal surface (I. M. Braverman, "The Cutaneous microcirculation: ultrastructure and microanatomical organization", Microcirculation, Vol. 4, 1997, pages 329-340). Thus, measurement of optical  
 10 properties close to the surface of the skin can provide useful information on the effect of blood circulation on the concentration of metabolites in tissues that are close to the surface of the skin. Also, studies of blood circulation close to the surface of the skin by means of laser Doppler flowmetry have shown that laser Doppler flowmetry is a good tool for diagnosing peripheral circulatory disease.

15 Referring now to FIG. 1, the apparatus of this invention comprises a means for introducing light into tissue at a defined light introduction site. At small distances from the light introduction site are located a plurality of light collection sites, each light collection site being in contact with a light collecting element, which collects the light re-emitted from tissue. The intensity of the re-emitted light collected at this site  
 20 will be measured by a detector. The source of light for providing light at the light introduction site can be a focused beam of light, a collimated beam of light, or a surface-mounted light emitting diode or a laser diode in contact with the skin. Other sources of light can also be used. In addition, the source of light can be remote from the light introduction site, in which case an optical fiber can be used to carry light  
 25 from the remote source of light to the light introduction site. The re-emitted light is collected at each of multiple light collection sites located at specific distances,  $r_1$ ,  $r_2$ , ..., and  $r_n$ , from the light introduction site. The light collected is directed towards the detector that measures the intensity of the collected light. Re-emitted light can be collected by any of several means. Representative examples of these means of  
 30 collecting scattered light include, but are not limited to, fibers that are in contact with the skin and a mask with holes at predetermined distances from the light introduction site. The light thus collected can be imaged into a charge coupled device (CCD)

WO 01/09589

PCT/US00/20730

22

camera, a series of photodiodes in contact with the skin, a one-dimensional or a two-dimensional photodiode array, or any other suitable type of detector.

Although the previous discussion has focused primarily upon a single light introduction site and a plurality of light collection sites comprising light collecting  
5 elements, in an alternative embodiment, a plurality of light introduction sites and a single light collection site can be used. A single light collection site replaces the light introduction site, and a plurality of light introduction sites replaces the light collection sites at distances  $r_1$ ,  $r_2$ , ..., and  $r_n$ .

The apparatus of the present invention requires that the sites for introducing  
10 light and for collecting light be closely spaced. Thus, the apparatus is useful for monitoring analyte effects on the top skin layers, such as epidermis and dermis. The short sampling distances allowed for in this invention are in contrast with those disclosed in the prior art. As an example, Kumar et al. recommend that the separation between the light introduction site and the light collection site be greater  
15 than 4 mm, in order to avoid the structural effects of the surface of the skin. See G. Kumar, J. M. Schmitt, "Optical probe geometry for near-infrared spectroscopy of biological tissue", Applied Optics, Vol. 36, 1997, pages 2286-2293.

Another feature of this invention is that it provides a method and apparatus for selecting the optimal distance of separation between the light introduction site and  
20 the light collection site for the determination of an analyte. For analytes that significantly affect the scattering properties of the epidermis and the dermis layers by virtue of their effect on the refractive indexes, and hence the scattering coefficients of these layers, their concentrations can be determined at pre-selected short sampling distances. Thus, a distance in the range of 0.4 mm to 1.2 mm is appropriate for such  
25 a measurement. For these analytes, such as glucose, one can first generate a calibration relationship between their concentrations determined in vitro and the reflectance signals measured from the epidermis and the upper dermis. One can then use the calibration relationship thus generated to predict the concentrations of the analyte based on subsequent reflectance measurements.

30 On the other hand, analytes that affect deeper layers in the skin, such as hemoglobin, which is carried by blood flow into the upper and lower plexuses within dermis and subcutaneous tissue, can be determined from measurements at greater sampling distances. Thus, hemoglobin concentration and hematocrit can be better



WO 01/09589

PCT/US00/20730

23

measured at a longer sampling distance, e.g., greater than 1.4 mm. This longer distance corresponds to light re-emitted from skin layers deeper than those encountered for the determination of glucose and other analytes that preferentially affect the optical properties of the upper layers of the skin. This invention offers a tunable sampling distance feature for optimizing analyte detection according to the nature of each analyte.

The properties of skin layers vary from one body part to another and from one individual to another. The difference includes the thickness of each skin layer, pigmentation and hydration state of the skin, tissues in the subcutaneous regions, effects of age and disease condition of the individual on the skin, etc. Thus, the sampling depth and hence the sampling distance at which an analyte should be optimally determined varies by the body part and the individual to be tested.

Other analytes that can be determined by the method and apparatus of this invention include tissue hemoglobin, tissue urea and creatinine, and skin water content. These analytes can be determined individually by selecting the optimal sampling distance for each analyte determination or simultaneously by measuring light re-emitted at multiple sampling distances and correlating each analyte at its optimum sampling distance for maximum correlation with the reference method.

In another aspect, this invention provides a method for the establishment of a calibration relationship for the in vivo measurement of an analyte. A calibration relationship, applicable to a given analyte, a given individual, and a given body part, determines the optimum sampling distance and subsequently the optimum sampling depth in the tissue. It also provides the correlation relationship between the concentration of a given analyte in the sample and the intensity of the re-emitted light detected at the optimum sampling distance. For each analyte and each individual, the method for generating a calibration relationship comprises the steps of:

(1) employing one of the non-invasive methods described herein to make at least one measurement of the concentration of an analyte, by measuring the reflectance of light at each of a plurality of sampling distances, and at substantially the same time, obtain the concentration of the analyte by a standard reference method;

WO 01/09589

PCT/US00/20730

24

(2) establishing the best achievable correlation relationship between the non-invasive measurement at each of the sampling distances and the concentration of the analyte;

(3) comparing the results obtained at each of the plurality of sampling distances; and

(4) selecting the sampling distance that provides the best correlation performance.

To accomplish step (2) above, one usually needs to test multiple mathematical relationships by means of regression methods such as the classical least squares and the principal component regression with respect to their performances. The performances are often measured by parameters such as the correlation coefficient and standard error of estimation in both the calibration process and the validation process. An optimal sampling distance should result in the best performance, as indicated by optimal statistical parameters, such as the highest correlation coefficient and the lowest standard error of estimation. The calibration relationship generated can be used for the subsequent determination of the concentration of the same analyte in the same individual, based only on a non-invasive measurement at a single appropriate sampling distance.

Standard reference methods can be used with this invention in the calibration procedure, so long as they are commonly accepted, in terms of specificity and sensitivity, by medical professionals, i.e., approved by the U. S. Food and Drug Administration, for the specified medical application. For example, commercial clinical chemistry analyzers can be used for determination of the concentrations of total serum bilirubin, blood hemoglobin, and venous blood glucose. The glucose meter commercially available for diabetics' self use can be used to measure glucose concentration in the blood from a few microliters of capillary blood obtained, e.g., by lancing a finger. Microdialysis or other interstitial fluid sampling methods in combination with standard analytical chemistry methods may be used to determine the concentration of glucose in interstitial fluid samples. Hematocrit is commonly determined by centrifugation or cell sorting analyzers for venous blood samples.

WO 01/09589

PCT/US00/20730

25

FIG. 1 is a schematic diagram showing a light introduction site and several light collection sites located at several sampling distances from the light introduction site. Different tissue layers are probed at different sampling distances. The diffusely reflected light is measured, at each wavelength, for a fixed distance between the light introduction site and the light collection site. This configuration is achieved by using optical fibers in touch with the tissue surface. Selection of distance is achieved by interrogating the light collected at a given fiber at a given distance from the source fiber. This is a stationary illuminating and detecting system. The signal is amplified and is corrected for fluctuation of the light source and variation of the fiber throughput. The corrected signal is used for correlating with the analyte concentration to establish a calibration relationship or for the determination of the analyte.

Alternatively a non-stationary illumination and detection system can be used. The detection distance can be selected by moving the light introduction site on the surface of the sample using a mechanism similar to a compact disk (CD) player read head, to predetermined distances from a light collection site located at a specific site on the surface. Mechanisms for directing a light beam to predetermined distances include beam-stirring devices such as moving mirrors or prisms. The light beam can span a circular or linear path. Another method of achieving the same result involves illuminating a site on the surface of the sample using a stationary fiber in contact with the surface, or illuminating a point on the surface by a collimated or focused beam of light. Re-emitted light is then collected at selected sampling distances on the sample surface by moving a light collecting element on the surface. This can be affected by using a stylus-type (phonograph needle-type) arrangement.

The method of this invention is advantageous over the method disclosed European Patent No. 0 843 986, which does not appreciate the effect of weakly absorbing analytes, including glucose, on the scattering property of tissue layers. This patent does not disclose the method of determining different analytes with the use of different sampling distances, nor does it disclose the method of optimizing the sampling distance to accommodate differences in individuals.

The following non-limiting examples further illustrate this invention.

WO 01/09589

PCT/US00/20730

26

## **EXAMPLES**

### **Example 1**

5

This example shows an apparatus having selectable sampling distances through the use of a plurality of light collection fibers. FIG. 3 through FIG. 5 illustrate an example of an apparatus for the measurement of optical properties, and hence the concentration of different analytes at various depths in tissue. Co-pending U. S. Application Serial No. 09/198,049, filed November 23, 1998 ("Non-invasive sensor capable of determining optical parameters in a sample having multiple layers"), assigned to the assignee of this application, describes in detail many of the components used in the apparatus of this application. The apparatus was intended for introducing light into the skin on forearms of human subjects and measuring the light re-emitted therefrom. As shown in FIG. 3, the apparatus comprised a light source module 12, a human interface module 16, a signal detector module 18, and a branched optical fiber bundle 14 that conducted light signals among these three modules. Monochromatic light was generated from the light source module 12 at six wavelengths, i.e., 590 nm, 650 nm, 750 nm, 800 nm, 900 nm and 950 nm. The light was transported to the human interface module 16 through the source fiber 26 in the branched optical fiber bundle 14 (FIG. 4A and 4B). The source fiber 26 received light from its end housed in the source tip 20 in the light source module 12. It emitted the light into the skin of a subject's forearm from its other end, which directly touched the skin at a spot named the light introduction site, housed in the common tip 24 in the human interface module 16. Also touching the skin from the common tip 24, six other fibers 28, 30, 32, 34, 36 and 38 were six independent light collecting elements. Each of these fibers collected light re-emitted from the skin at the spot where it touched the skin, i.e., a light collection site. The human interface module engaged the common tip to the skin. It also provided temperature and pressure control mechanisms for the tip-skin contacting area. The area of skin surrounding the optical element engagement sites was kept at a predetermined constant temperature throughout the measurement. In addition, the human interface module had a comfortable armrest (not shown) for the testing forearm.

30

WO 01/09589

PCT/US00/20730

27

Both the source fiber and detection fibers were 400  $\mu\text{m}$  in diameter. The distance from any one detection fiber to the source fiber 26 at the end of the common tip 24 defined the distance between the corresponding light collection site on the skin and the light introduction site also on the skin, i.e., the sampling distances. These distances are indicated in FIG. 5 and listed in TABLE 1.

**TABLE 1**

	$r_1$	$r_2$	$r_3$	$r_4$	$r_5$	$r_6$
Sampling Distance, mm	0.44	0.78	0.92	1.22	1.40	1.84

The six detection fibers received the re-emitted light from the skin at the common tip 24 and transmitted the light to the detector tip 22 housed in the detector module 18. The ends of all of these fibers at the detector tip 22 were in the focal plane of a lens for the detector (both lens and detector are not shown). However, only when the shutter between a particular fiber end and the detector (not shown) was opened was the light signal from that fiber detected.

Therefore, the sampling depth was determined by selecting a particular light collection fiber and detecting the intensity of re-emitted light collected by this fiber. Selection of a particular light collection fiber was achieved by the use of a programmable shutter that selected one of the six light collection fibers. The shutter was moved by rotating the shutter to a programmed number of steps or a pre-selected detent on its mount.

**Example 2**

This example illustrates the correlation of non-invasive measurements to hemoglobin concentration or hematocrit. An apparatus as described in FIG. 3 through FIG. 5 was used for the in vivo determination of hemoglobin content and hematocrit for 28 subjects. Some of these subjects were diabetics and some had dark skin.

WO 01/09589

PCT/US00/20730

28

Tests were conducted on the subjects three hours after their breakfast meal. Non-invasive measurements were performed on the inner part of the subject's left forearm. Silicone oil (Poly(dimethylsiloxane), 200® fluid, viscosity 1,000 cSt, Aldrich Chemical Company) was applied to the skin, and the human interface module 16  
 5 with the common tip 24 was placed in contact with the skin. The temperature of the testing site on the skin was allowed to equilibrate at 34 °C for two minutes, and then the measurement was started. Reflected light was collected and reflectance was measured at the six sampling distances as shown in TABLE 1. Wavelengths used in this measurement were 590, 650, 750, 800, 900, and 950 nm.

10 Venous blood samples of the subjects were obtained immediately following the non-invasive measurement and used for determination of the reference values of hemoglobin concentration and hematocrit. The hematocrit value was determined by a standard micro-centrifuge method (described in C. E. Seiverd, Hematology for Medical Technologists, Lea & Febiger, Philadelphia PA , 1983, pages 320-330).  
 15 Blood hemoglobin values were determined using a commercial kit and a commercial clinical chemistry analyzer (Vision® Analyzer, Abbott Laboratories, North Chicago, IL).

The relative reflectance at detection distance  $r$ ,  $R(r)$  is defined as:

$$R(r) = \frac{I_{\text{reflected}}(r)}{I_{\text{incident}}} \quad (4)$$

20 where,

$I_{\text{incident}}$  represents the relative intensity of the illuminating light from the source fiber 26 measured from the common tip 24; and,

$I_{\text{reflected}}(r)$  represents the relative intensity of the re-emitted light from the skin collected by a light collection fiber which has distance  $r$  to the source fiber  
 25 26 at the common tip 24, and measured at the detector module 18.

Reflectance data at different sampling distances and wavelengths was correlated with the hematocrit and hemoglobin concentrations by means of the linear least square method. For hematocrit, the correlation coefficient was low at the  
 30 shorter sampling distances (e.g., 0.44 mm and 0.78 mm) and increased significantly at sampling distances greater than about 0.92 mm. The reflectance at a fixed sampling distance of 1.84 mm yielded the highest correlation coefficient and the

WO 01/09589

PCT/US00/20730

29

lowest standard error of calibration for correlation with reference hematocrit values. The correlation coefficient was plotted as a function of sampling distance and the plot is shown in Figure 6. The correlation coefficient was above 0.9 at distances of 1.40 mm and 1.84 mm. At either of these two distances, the light penetrates through the upper plexus and encounters blood capillaries. The standard error of calibration followed a reverse trend, being greater than 3.2% at the shorter distances and less than 2.0% at the two greater distances. The best regression plot is shown in FIG. 7 and the regression equation is:

$$\begin{aligned} \text{Hematocrit (\%)} = & -0.347 - 39.0 \bullet \text{Log}[R(590 \text{ nm})] + 61.0 \bullet \text{Log}[R(650 \text{ nm})] \\ & + 151 \bullet \text{Log}[R(900 \text{ nm})] - 178 \bullet \text{Log}[R(950 \text{ nm})] \end{aligned} \quad (5)$$

where,  $\text{Log}[R(\lambda)]$  represents the natural logarithm of reflectance at wavelength  $\lambda$  (nm) and at a sampling distance of 1.84 mm. The correlation coefficient is 0.911 and the standard error of calibration is 1.84 % (hematocrit unit) for the 28 subjects.

A similar correlation was obtained with the use of absorption and scattering coefficients deriving from reflectance values at the all six different sampling distances. This method was described in the prior art (e. g., U. S. Patent No. 5,075,695 and U. S. Patent No. 5,551,422). However, this example demonstrated the correlation with diffuse reflectance data at much shorter sampling distances (instead of greater than 5 mm in the prior art) and using a temperature controlled detection device. The regression equation thus obtained is:

$$\begin{aligned} \text{Hematocrit (\%)} = & 55.8 + 11.4 \bullet \mu_a(590 \text{ nm}) - 26.1 \bullet \mu_a(650 \text{ nm}) \\ & 5.72 \bullet \mu_s'(590 \text{ nm}) + 6.14 \bullet \mu_s'(650 \text{ nm}) \end{aligned} \quad (6)$$

The correlation coefficient was 0.87 for the 28 subjects as a group and the standard error of calibration was 2.2% (hematocrit unit).

Thus, the use of reflectance data from a specific sampling depth, collected at a single optimized sampling distance yielded a better correlation and smaller standard error of calibration with respect to the reference values of the hematocrit than does the use of the fitted absorption and scattering coefficient values.

WO 01/09589

PCT/US00/20730

30

Furthermore, the measurement does not require synchronizing to heart beat pulses or a pulsatile signal as taught by U. S. Patent Nos. 5,499,627 and 5,803,908.

From the plot of the correlation coefficient and the standard error of calibration as a function of sampling distance (FIG. 6), it is apparent that quality of regression is no longer sensitive to the sampling distance when the distances are greater than 1.4 mm.

Skin color was found to affect the calculation that was based on the absorption and scattering coefficients. Thus, it is possible to improve the correlation with hematocrit by eliminating data points corresponding to dark-skinned individuals. In this case the number of light-skinned subjects was 24 and the regression equation becomes:

$$\text{Hematocrit (\%)} = 26.2 + 21.7 \cdot \mu_a(590 \text{ nm}) - 26.4 \cdot \mu_a(650 \text{ nm}) - 32.6 \cdot \mu_a(800 \text{ nm}) + 33.6 \cdot \mu_a(950 \text{ nm}) \quad (7)$$

The correlation coefficient is 0.90 and the standard error of calibration is 1.8% (hematocrit unit).

Effects of skin color were minimized in the correlation to the hematocrit, when the reflectance measured at a single sampling distance and generated from a fixed sampling depth in skin was used. This result is in agreement with the layered structure description of human skin tissue described herein, as at this distance, light penetrates the upper plexus of the dermis layer of the skin and encounters the blood capillaries. Those skilled in the art can use similar analysis and apply this measurement method to other analytes.

### **Example 3**

This example illustrates non-invasive glucose correlation. The same apparatus as described in Example 1 and a similar setup as described in Example 2 were used for the in vivo determination of glucose for three subjects. For each individual subject, a meal tolerance test protocol was used to induce changes in blood glucose. Correlation between the reflectance measurement and the reference in vitro blood test was carried out.



WO 01/09589

PCT/US00/20730

31

For each subject, the reflectance measurement was performed repetitively with one set of readings (at six sampling distances as shown in TABLE 1 and at three wavelengths - 590 nm, 800 nm and 950 nm) for every 100 seconds. Tests were conducted under controlled skin temperature of 22 °C. Blood samples were taken from the subject by means of a finger-stick every 5 to 15 minutes and tested by means of a commercially available glucose meter. The measurement started when the subject was in a fasting condition. After 10 to 20 minutes, the subject ingested a high sugar drink (commercially available fruit juices, 680-mL liquid and 100 to 120 gram sugars). The total measurement required 90 minutes to 120 minutes.

A plot of the glucose values vs. the time during the meal tolerance test on one of the subjects is shown in FIG. 8. The circles represent the result of the reference glucose test using finger-stick capillary blood and a home glucose meter (Glucometer Elite®, Bayer Corp., Elkhart, IN). The smooth line passing through these circles shows the fit values of reference glucose concentration resulting from cubic spline smoothing of the finger-stick capillary blood glucose values. Interpolated data points represent the in vitro blood glucose test results at points in time that do not coincide with the points in time at which the tests were actually performed. Classical linear regression was employed to correlate a model comprising reflectance measurement at each single sampling distance at three wavelengths with the fit values of reference glucose concentrations. In most cases, reflectance measurements at  $r_3$  ( $r = 0.92$  mm) at three wavelengths yielded a linear model and fit to the reference glucose values. In FIG. 8, the crosses represent the values of glucose concentration calculated by such a model, i. e.,

$$\text{Glucose (mg/dL)} = -2898 + 536 \cdot \text{Log}[R(590 \text{ nm})] - 1523 \cdot \text{Log}[R(800 \text{ nm})] + 2043 \cdot \text{Log}[R(950 \text{ nm})] \quad (8)$$

where,  $\text{Log}[R(\lambda)]$  represents the natural logarithm of reflectance at wavelength  $\lambda$  (nm). The models yielded a correlation coefficient of 0.98 and a standard error of calibration of 8.9 mg/dL.

Two of the three subjects were non-diabetics, and the third was diagnosed as a diabetic in less than one year. The meal tolerance test was performed on one of

WO 01/09589

PCT/US00/20730

32

the non-diabetic subjects twice in two days. For each of four meal tolerance tests, the reflectance measurement at single distance (0.92 mm) was used to correlate with the reference blood glucose concentration. The calibration results of the four tests are compiled in a Clark error grid presentation, as shown in FIG. 9, where the  
5 calculated glucose values are plotted against the reference glucose values. The total number of data points is 250. As seen from the plot, 96% of the data points are in Zone A, the rest are in Zone B, and none is in the zones C, D or E. While data in Zone A and Zone B are considered "acceptable" performance, data in Zones C, D and E may cause serious adverse effects in clinical applications, as they may lead to  
10 the wrong types of medical intervention.

Thus reflectance measurement at a single sampling distance that targets the epidermis and the upper dermal layers (sampling distances shorter than 0.92 mm) leads to a good correlation with the concentration of glucose during a meal tolerance test. Such a measurement is simpler than the use of spatially resolved  
15 measurement as taught by U. S. Patent Nos. 5,075,695 and 5,551,442 where signals at multiple sampling distances are needed. Those who are skilled in the art can use some data sets as calibration sets and predict the others using prior art chemometric methods.

Because measurements can be carried out at wavelengths ranging from 400  
20 nm to 2500 nm, the method of this invention avoids the limitations of the method described in EP 0 843 986. In EP 0 843 986, a light beam having a wavelength ranging from 1300 nm to 2500 nm is projected into the skin and the re-emitted light is detected at distances of 0.1-2 mm from the source of light. The spectrum of skin in the 1300-2500 nm range is dominated by water absorption. The path length in the  
25 tissue is limited because of strong water absorption. Collecting the signal at the short distances will not allow a significant absorption change due to the weakly absorbing glucose to be measured.

It is important to mention that the determination of hematocrit and hemoglobin (i.e., Example 2), as well as the determination of glucose were performed with the  
30 same instrument and the same optical sensor, by programming to use a particular sampling distance for either glucose or hematocrit. One of ordinary skill in the art can configure other distances for other analytes and optimize the measurement for a

WO 01/09589

PCT/US00/20730

33

particular body part that has different thickness of skin layer, a particular individual, or a group of individuals.

Selected distances  $r_2$  (0.78 mm) and  $r_3$  (0.92 mm) provided the best correlation for glucose determination, depending on testing temperature used. In another set of experiments, selected distance  $r_1$  (0.44 mm) provided the best correlation for measurement at 38 °C. Thus, distances of less than 1 mm led to a better correlation with the glucose concentrations for the individuals and the body part tested.

At short sampling distances, measurement of signals from shallower sampling depth and with greater contribution from scattering properties yields good correlation with weakly absorbing analytes such as glucose. Glucose would be expected to affect the refractive index of the dermis and the epidermis and change their scattering properties. At large distances from the light introduction site, re-emitted light has greater contribution from absorption and is originated from deeper layers. Blood capillaries distributed in the upper and lower plexus regions of the skin would be expected to affect signals from these regions. Thus, the measurement gives a better correlation with hemoglobin and hematocrit, as demonstrated in Example 2.

Various modifications and alterations of this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention, and it should be understood that this invention is not to be unduly limited to the illustrative embodiments set forth herein.

WO 01/09589

PCT/US00/20730

34

What is claimed is:

1. A method for determining the concentration of an analyte in a biological sample, said method comprising the steps of:

5

(a) introducing a beam of light into said biological sample at a light introduction site on a surface of said biological sample;

10

(b) collecting the light re-emitted from said biological sample at a light collection site on said surface of said biological sample, said light collection site located at a distance from said light introduction site, said distance of said light collection site from said light introduction site corresponding to a sampling depth in said biological sample, at which sampling depth an optical property of said biological sample is significantly affected by said analyte;

15

(c) determining the intensity of said collected light; and,

(d) determining the concentration of said analyte from said intensity of said collected light.

20

2. The method of claim 1, wherein said biological sample has a plurality of layers and said sampling depth corresponds to a layer in said biological sample.

3. The method of claim 1, wherein the concentration of said analyte is determined by means of a calibration relationship.

25

4. The method of claim 1, wherein the intensity of said collected light is determined at a plurality of wavelengths.

5. The method of claim 4, wherein said wavelengths range from about 400 nm to about 2500 nm.

30

6. The method of claim 4, wherein said wavelengths range from about 400 nm to about 1300 nm.

WO 01/09589

PCT/US00/20730

35

7. The method of claim 1, wherein said optical property affected by said analyte is scattering of light.

5 8. The method of claim 1, wherein said optical property affected by said analyte is light absorption.

9. The method of claim 1, wherein said analyte is glucose.

10 10. The method of claim 1, wherein said analyte is hemoglobin.

11. The method of claim 1, wherein said biological sample is a human tissue.

12. A method for determining the concentrations of a plurality of analytes in a biological sample, said method comprising the steps of:

(a) introducing a beam of light into said biological sample at a light introduction site on a surface of said biological sample;

20 (b) collecting the light re-emitted from said biological sample at at least one light collection site on said surface of said biological sample, said at least one light collection site located at a distance from said light introduction site, said distance of said at least one light collection site from said light introduction site corresponding to a sampling depth in said biological sample, at which sampling depth an optical property of said biological sample is significantly affected by one of said plurality of analytes;

25 (c) determining the intensity of said collected light;

(d) determining the concentration of said one of said plurality of analytes from said intensity of said collected light; and

30 (e) repeating steps (a), (b), (c), and (d) for at least another of said plurality of analytes.

WO 01/09589

PCT/US00/20730

36

13. The method of claim 12, wherein said biological sample has a plurality of layers and said sampling depth corresponds to a layer in said biological sample.

5 14. The method of claim 12, wherein the concentrations of said analytes are determined by means of calibration relationships.

15. The method of claim 12, wherein the intensity of said collected light is determined at a plurality of wavelengths.

10

16. The method of claim 15, wherein said wavelengths range from about 400 nm to about 2500 nm.

17. The method of claim 15, wherein said wavelengths range from about 400 nm to about 1300 nm.

15

18. The method of claim 12, wherein said optical property affected by said one of said plurality of analytes is scattering of light.

20 19. The method of claim 12, wherein said optical property affected by said one of said plurality of analytes is light absorption.

20. The method of claim 12, wherein one of said plurality of analytes is glucose.

25

21. The method of claim 12, wherein one of said plurality of analytes is hemoglobin.

22. The method of claim 12, wherein said biological sample is a human tissue.

30

23. The method of claim 12, wherein step (e) is carried out subsequent to steps (a), (b), (c), and (d).

WO 01/09589

PCT/US00/20730

37

24. The method of claim 12, wherein step (e) is carried out simultaneously with steps (a), (b), (c), and (d).

5 25. A method for determining the concentrations of a plurality of analytes in a biological sample, said method comprising the steps of:

(a) introducing light into said biological sample at at least one light introduction site on a surface of said biological sample;

10 (b) collecting the light re-emitted from said biological sample at a light collection site on said surface, said light collection site located at a distance from said at least one light introduction site, said distance of said light collection site from said at least one light introduction site corresponding to a sampling depth in said biological sample, at which sampling depth an optical property of said biological  
15 sample is significantly affected by one of said plurality of analytes;

(c) determining the intensity of said collected light;

(d) determining the concentration of said one of said plurality of analytes from said intensity of said collected light; and

(e) repeating steps (a), (b), (c), and (d) for at least another of said plurality  
20 of analytes.

26. The method of claim 25, wherein said biological sample has a plurality of layers and said sampling depth corresponds to a layer in said biological sample.

25

27. The method of claim 25, wherein the concentrations of said analytes are determined by means of calibration relationships.

28. The method of claim 25, wherein the intensity of said collected light is  
30 determined at a plurality of wavelengths.

29. The method of claim 28, wherein said wavelengths range from about 400 nm to about 2500 nm.

WO 01/09589

PCT/US00/20730

38

30. The method of claim 28, wherein said wavelengths range from about 400 nm to about 1300 nm.

5 31. The method of claim 25, wherein said optical property affected by said one of said plurality of analytes is scattering of light.

32. The method of claim 25, wherein said optical property affected by said one of said plurality of analytes is light absorption.

10 33. The method of claim 25, wherein one of said plurality of analytes is glucose.

15 34. The method of claim 25, wherein one of said plurality of analytes is hemoglobin.

35. The method of claim 25, wherein said biological sample is a human tissue.

20 36. The method of claim 25, wherein step (e) is carried out subsequent to steps (a), (b), (c), and (d).

37. The method of claim 25, wherein step (e) is carried out simultaneously with steps (a), (b), (c), and (d).

25 38. A method for generating a calibration relationship for measuring at least one analyte in a biological sample, said method comprising the steps of:

(a) introducing a beam of light into said biological sample at a light introduction site on a surface of said biological sample;

30 (b) collecting the light re-emitted from said biological sample at each of a plurality of light collection sites on said surface, each of said plurality of light collection sites being at a different sampling distance from said light introduction site;



WO 01/09589

PCT/US00/20730

39

(c) determining the intensity of said light collected at each of said plurality of light collection sites;

(d) determining a correlation relationship between said intensity of said light collected at each of said plurality of light collection sites with the concentration of said at least one analyte, said concentration determined by an independent reference method;

(e) comparing said correlation relationships for said different sampling distances; and

(g) determining an optimal sampling distance for said at least one analyte for subsequent measurement of the concentration of said at least one analyte in a biological sample.

39. The method of claim 38, wherein said at least one analyte is a component of the blood.

40. The method of claim 38, wherein said at least one analyte is a component of interstitial fluid.

41. The method of claim 38, wherein the intensity of said collected light is determined at a plurality of wavelengths.

42. The method of claim 41, wherein said wavelengths range from about 400 nm to about 2500 nm.

43. The method of claim 41, wherein said wavelengths range from about 400 nm to about 1300 nm.

44. The method of claim 38, wherein said optical property affected by said at least one analyte is scattering of light.

45. The method of claim 38, wherein said optical property affected by said at least one analyte is light absorption.

WO 01/09589

PCT/US00/20730

40

46. The method of claim 38, wherein said at least one analyte is glucose.

47. The method of claim 38, wherein said at least one analyte is hemoglobin.

48. The method of claim 38, wherein said biological sample is a human tissue.

49. A method for generating a calibration relationship for measuring at least one analyte in a biological sample, said method comprising the steps of:

(a) introducing a beam of light into said biological sample at each of a plurality of light introduction sites on a surface of said biological sample;

(b) collecting the light re-emitted from said biological sample at a light collection site on said surface, each of said plurality of light introduction sites being at a different sampling distance from said light collection site;

(c) determining the intensity of said light collected for each of said plurality of light introduction sites;

(d) determining a correlation relationship between said intensity of said light collected for each of said plurality of light introduction sites with the concentration of said at least one analyte, said concentration determined by an independent reference method;

(e) comparing said correlation relationships said different sampling distances; and

(g) determining an optimal sampling distance for said at least one analyte for subsequent measurement of the concentration of said at least one analyte in a biological sample.

50. The method of claim 49, wherein said at least one analyte is a component of the blood.

51. The method of claim 49, wherein said at least one analyte is a component of interstitial fluid.

WO 01/09589

PCT/US00/20730

41

52. The method of claim 49, wherein the intensity of said collected light is determined at a plurality of wavelengths.

53. The method of claim 52, wherein said wavelengths range from about  
5 400 nm to about 2500 nm.

54. The method of claim 52, wherein said wavelengths range from about 400 nm to about 1300 nm.

10 55. The method of claim 49, wherein said optical property affected by said at least one analyte is scattering of light.

56. The method of claim 49, wherein said optical property affected by said at least one analyte is light absorption.  
15

57. The method of claim 49, wherein said at least one analyte is glucose.

58. The method of claim 49, wherein said at least one analyte is hemoglobin.  
20

59. The method of claim 49, wherein said biological sample is a human tissue.

60. An apparatus for the determination of an analyte in a biological sample,  
25 said apparatus comprising:

(a) a means for introducing a beam of light into said biological sample at at least one light introduction site on a surface of said biological sample;

(b) a means for collecting light re-emitted from said biological sample at at  
30 least one light collection site on said surface located at a predetermined sampling distance from said at least one light introduction site, said predetermined sampling distance corresponding to a sampling depth, at which sampling depth an optical property of said biological sample is significantly affected by said analyte;

WO 01/09589

PCT/US00/20730

42

- (c) a means for determining the intensity of said collected light; and
- (d) a means for determining the concentration of said analyte.

5 61. The apparatus of claim 60, wherein said means for determining the concentration of said analyte comprises a computer.

62. The apparatus of claim 60, further comprising a means for selecting at least one wavelength for said light introduced into said biological sample or said re-emitted light from said biological sample.

10 63. The apparatus of claim 62, wherein said at least one wavelength is in 400 nm to 2500 nm range.

15 64. The apparatus of claim 62, wherein said at least one wavelength is in 400 nm to 1300 nm range.

65. The apparatus of claim 60, wherein said optical property affected by said analyte is scattering of light.

20 66. The apparatus of claim 60, wherein said optical property affected by said analyte is light absorption.

67. The apparatus of claim 60, wherein said analyte is glucose.

25 68. The apparatus of claim 60, wherein said analyte is hemoglobin.

69. The apparatus of claim 60, wherein said biological sample is human tissue.

30 70. The apparatus of claim 60, wherein said means (a) comprises a single illuminating element and said means (b) comprises a plurality of light collecting elements.

WO 01/09589

PCT/US00/20730

43

71. The apparatus of claim 60, wherein said means (a) comprises a plurality of illuminating elements and said means (b) comprises a single light collecting element.

5 72. The apparatus of claim 60, wherein said means (a) comprises a single illuminating element capable of moving along the surface of said biological sample.

73. The apparatus of claim 60, wherein said means (b) comprises a single light collecting element capable of moving along the surface of said biological  
10 sample.

WO 01/09589

PCT/US00/20730

1 / 13

FIG. 1A

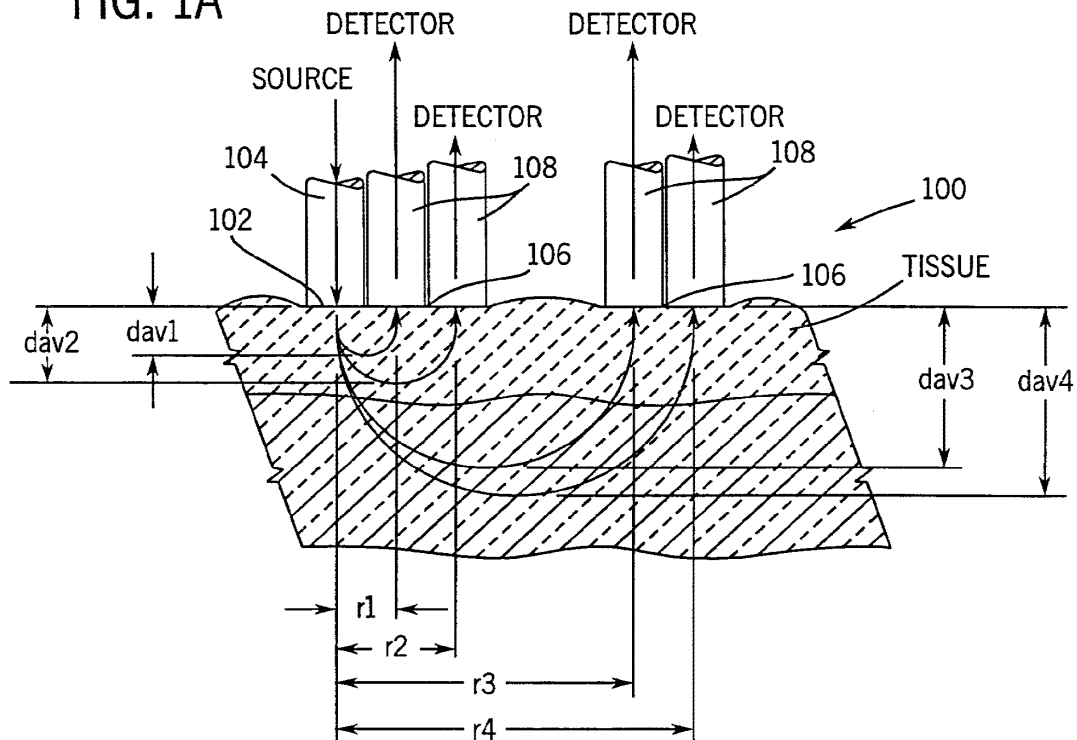


FIG. 2

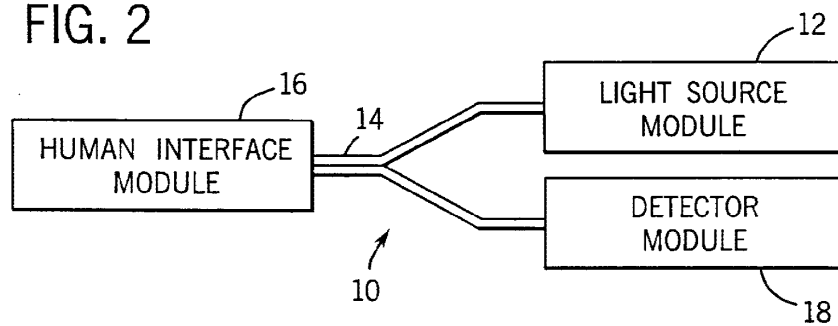
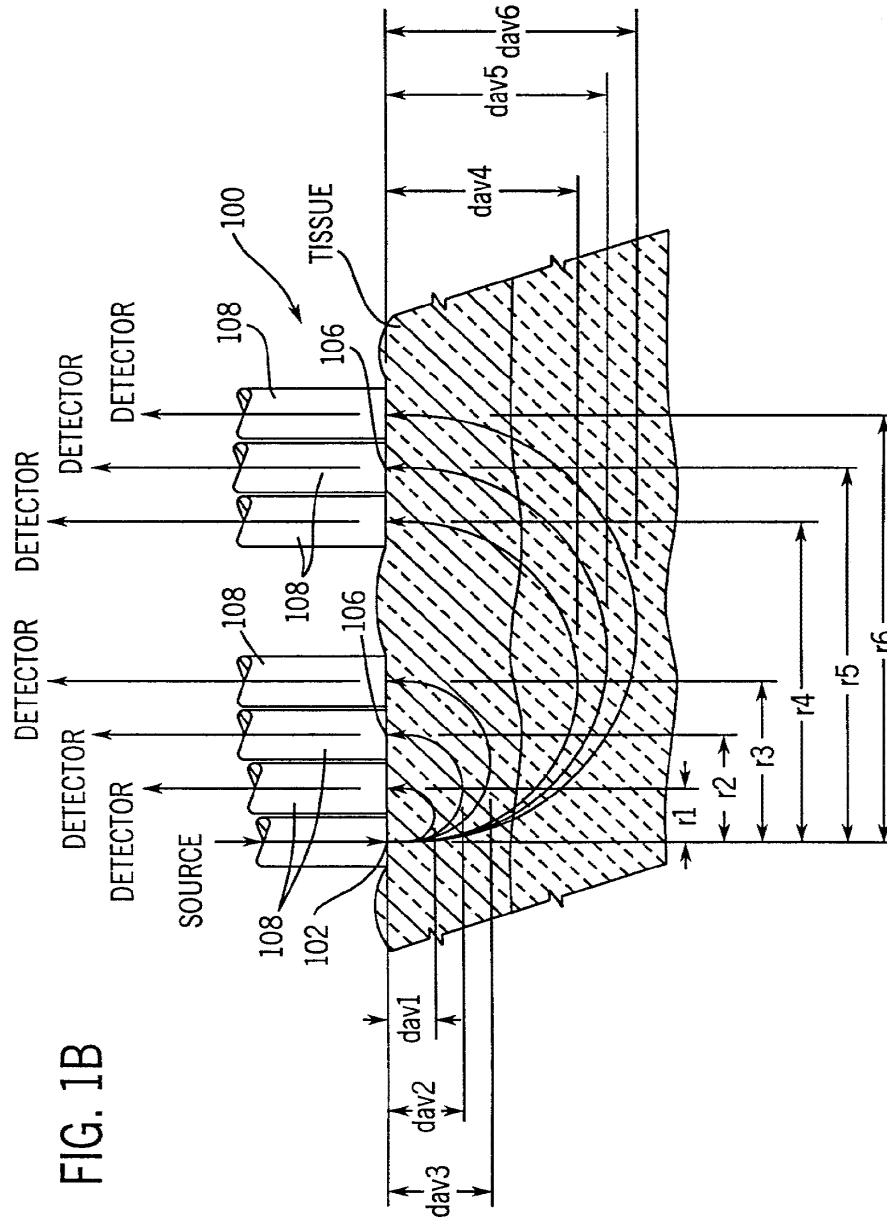


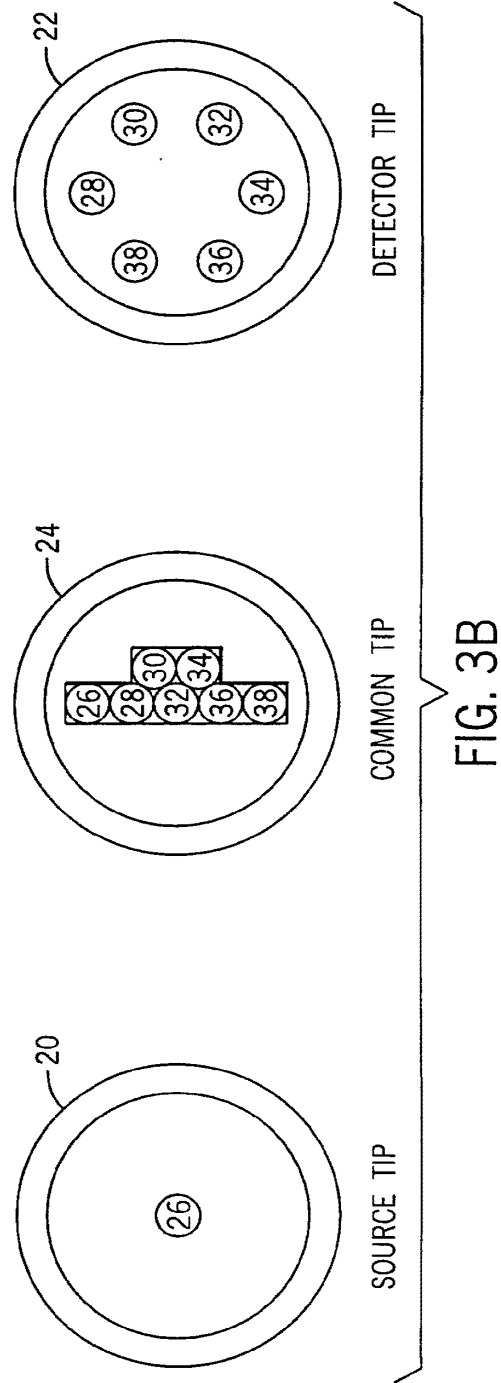
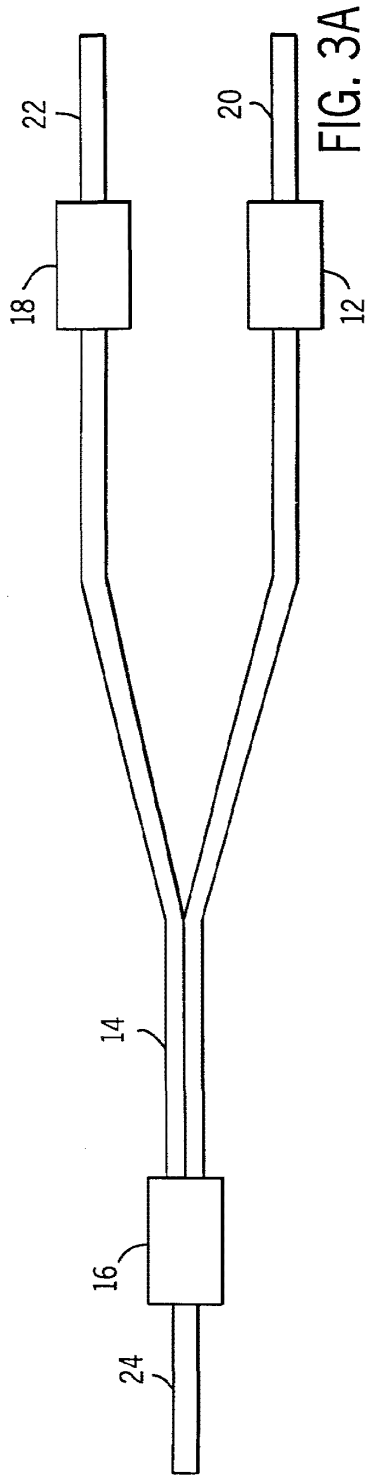
FIG. 1B



WO 01/09589

PCT/US00/20730

3 / 13





WO 01/09589

PCT/US00/20730

4 / 13

FIG. 4

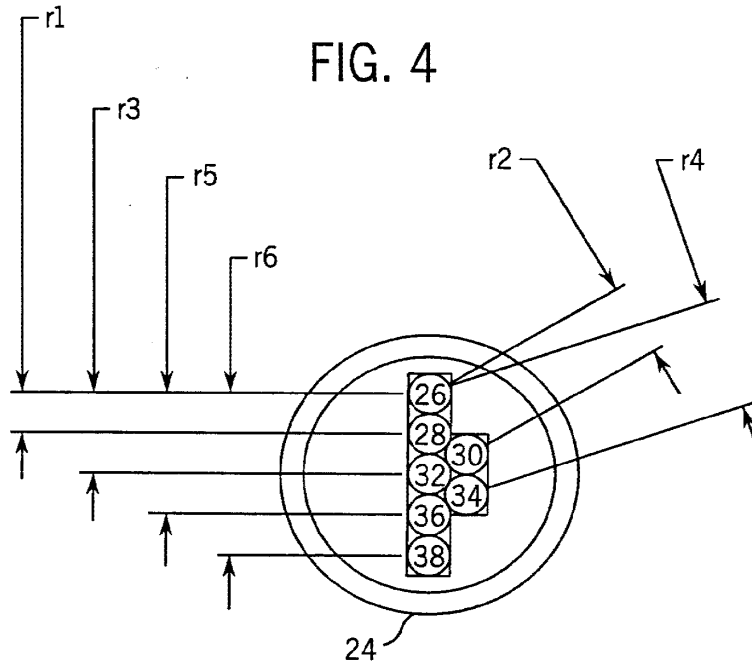
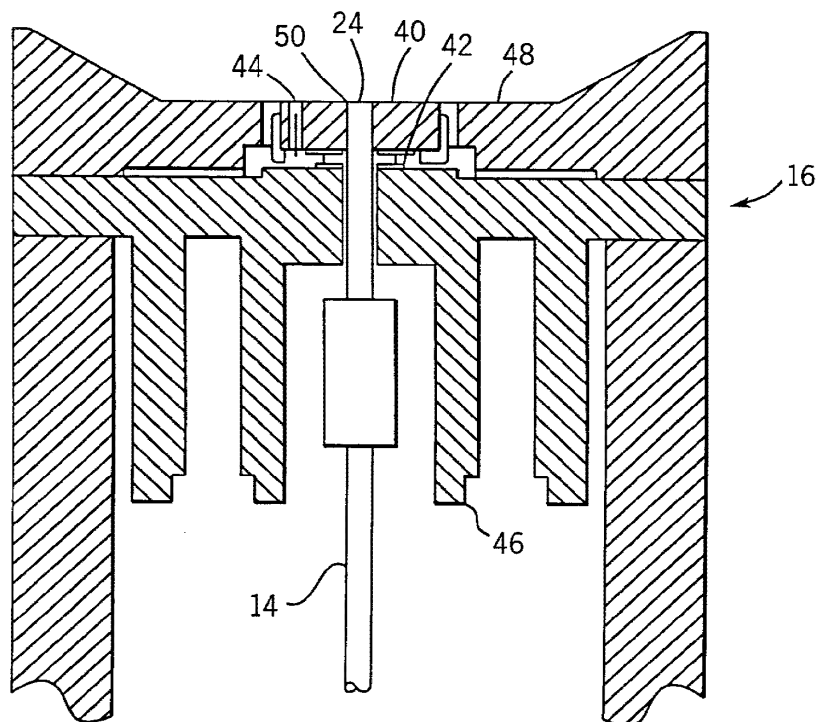


FIG. 5



WO 01/09589

PCT/US00/20730

5 / 13

FIG. 6A

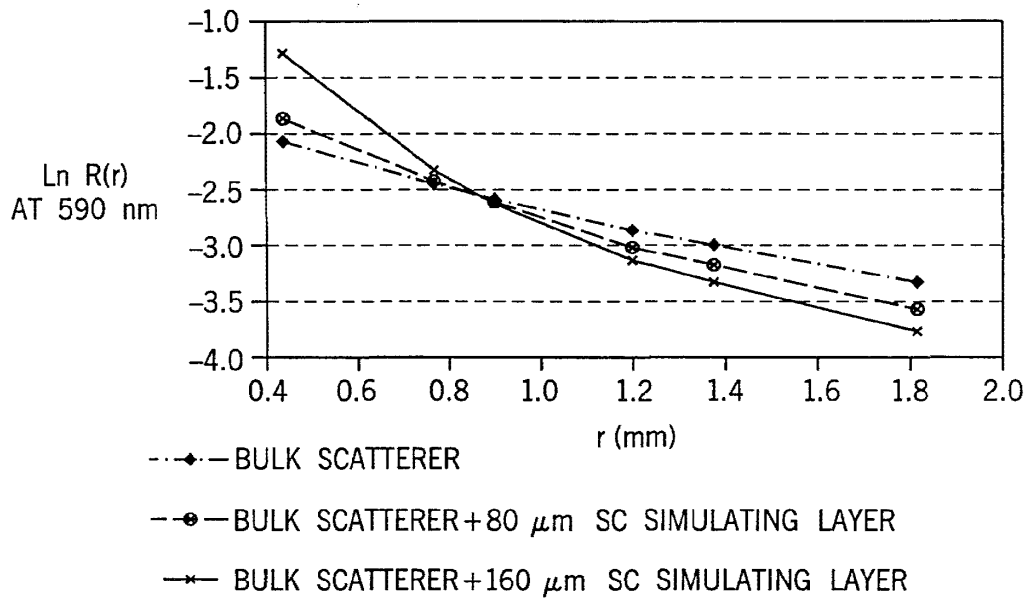
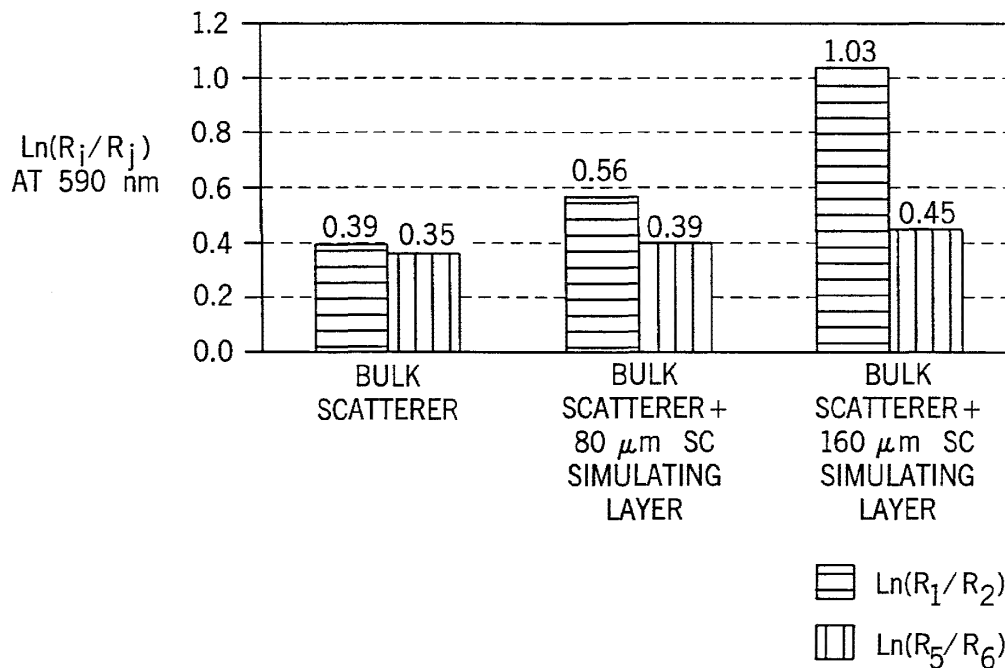


FIG. 6B



WO 01/09589

PCT/US00/20730

6 / 13

FIG. 7A

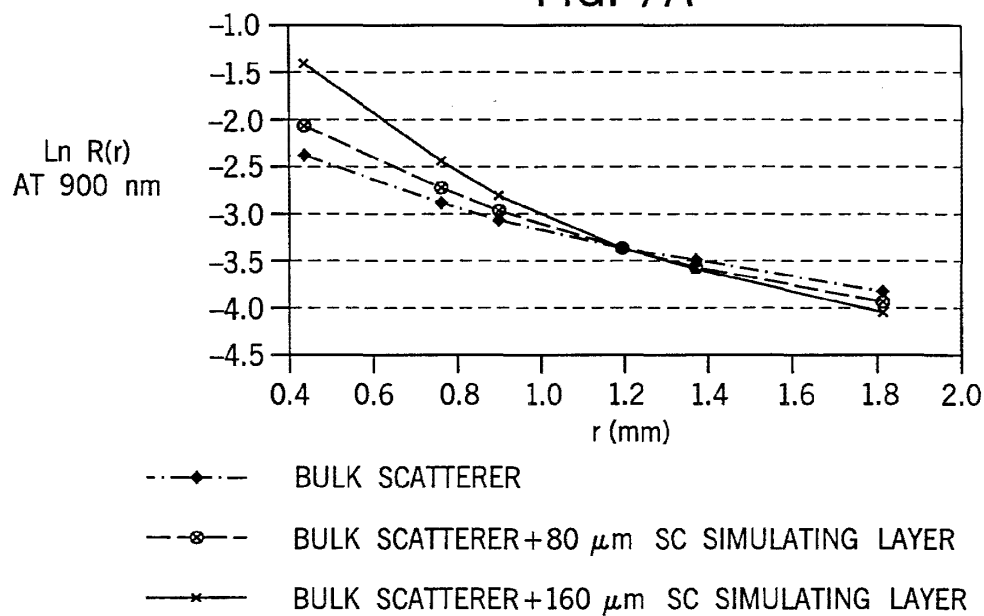
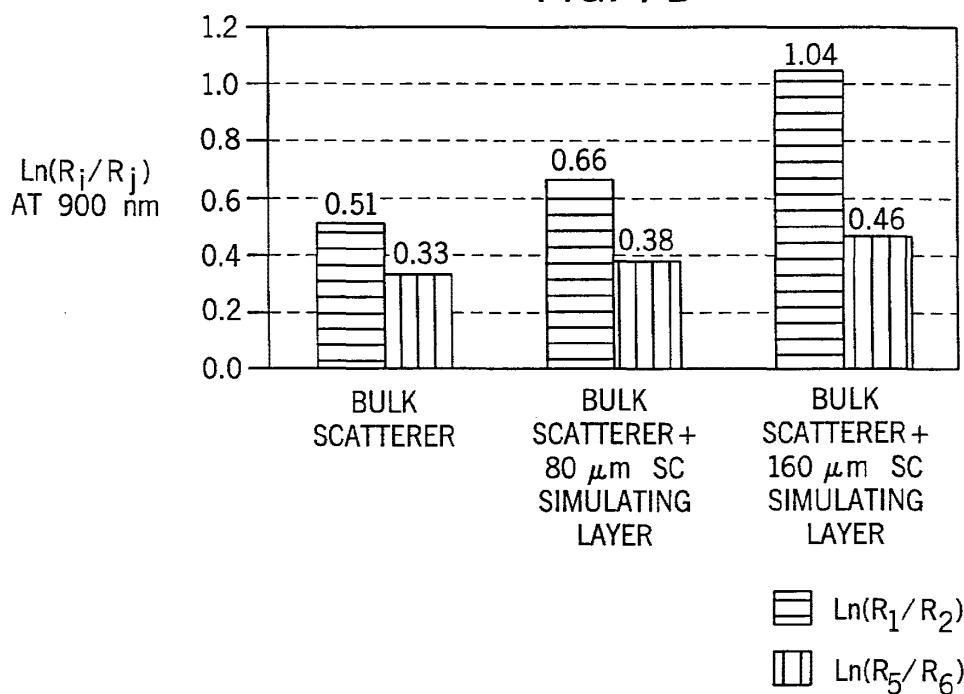


FIG. 7B



WO 01/09589

PCT/US00/20730

7 / 13

FIG. 8A

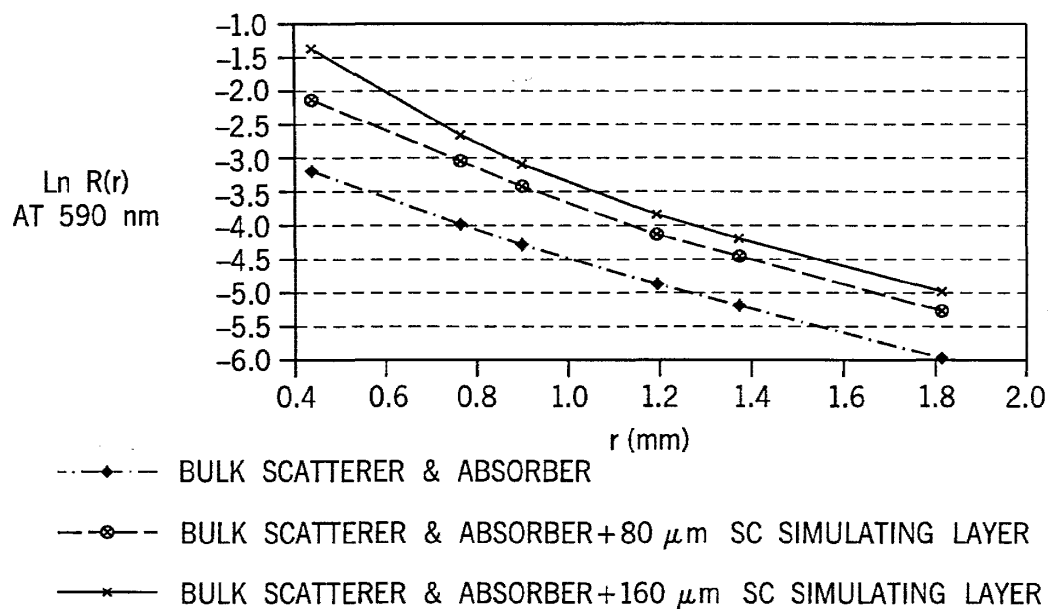
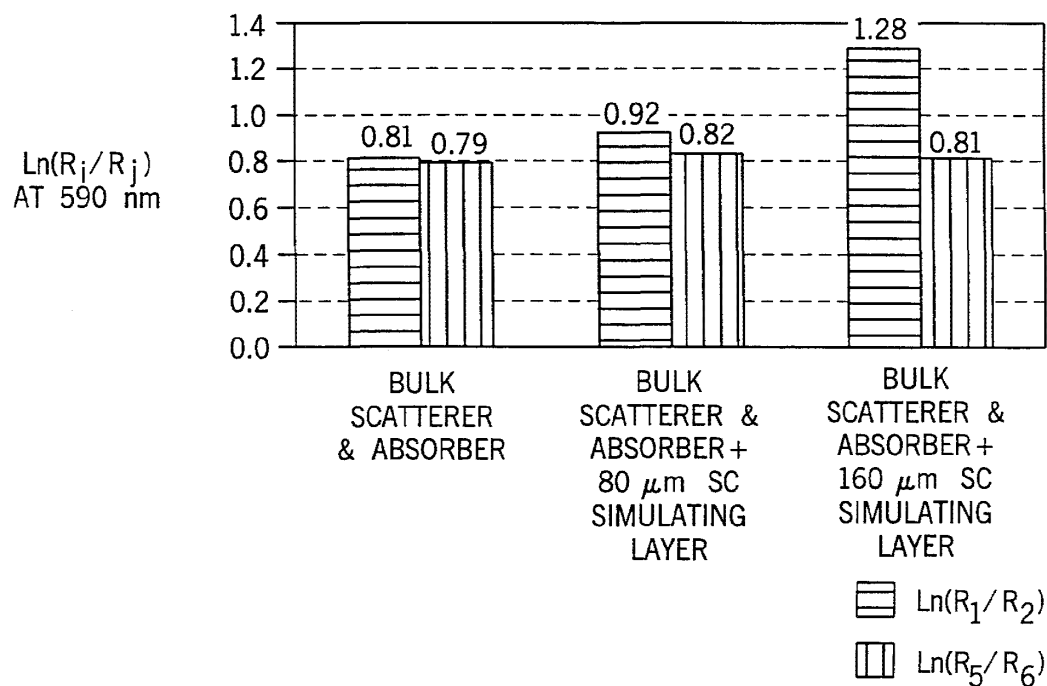


FIG. 8B



WO 01/09589

PCT/US00/20730

8 / 13

FIG. 9A

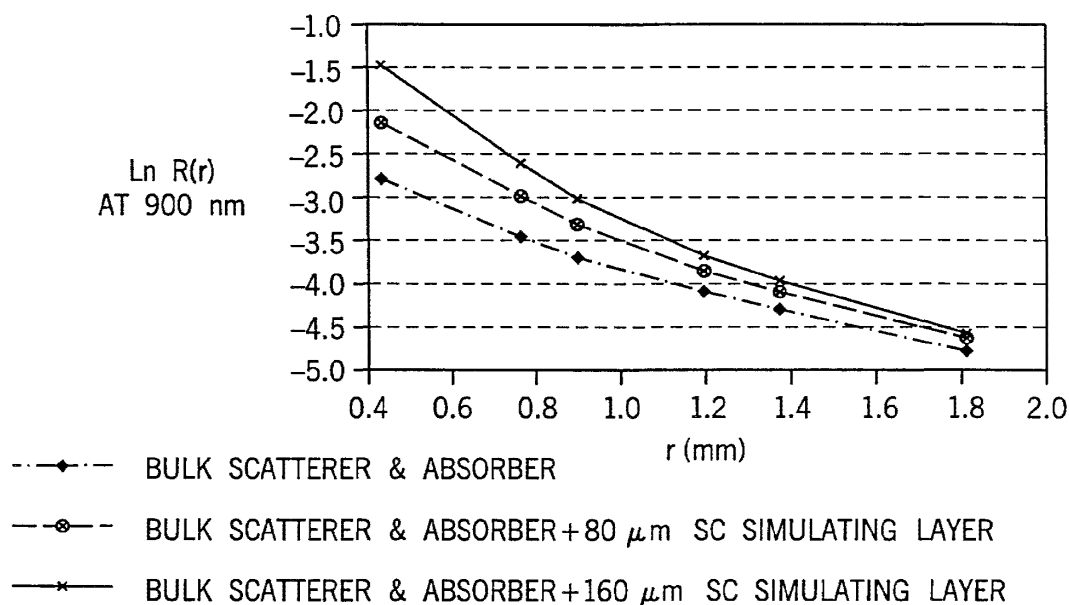
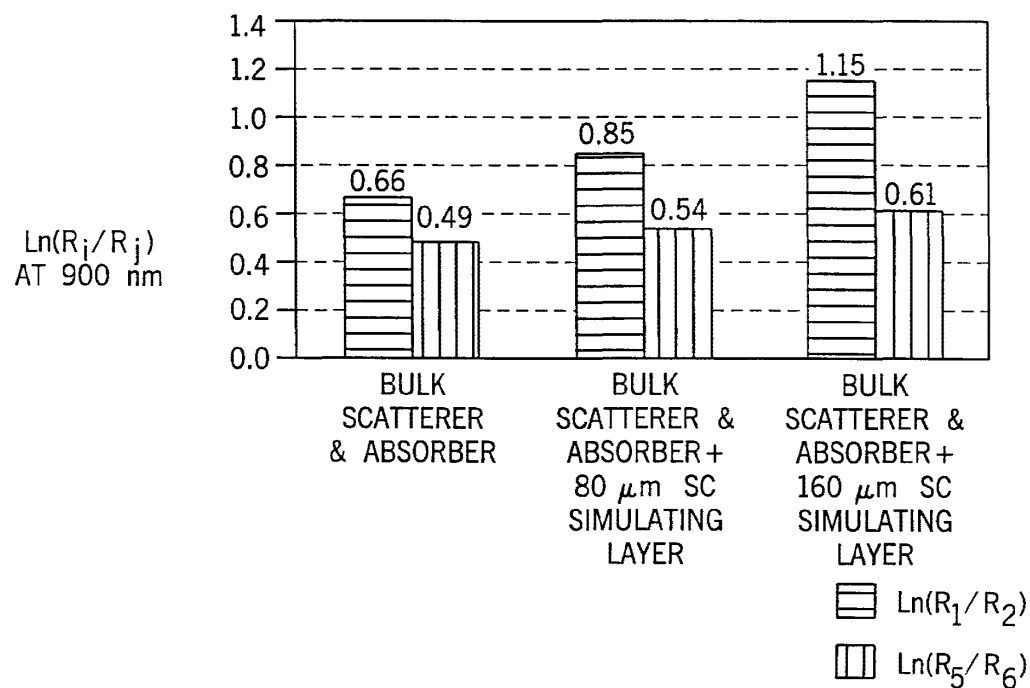


FIG. 9B



WO 01/09589

PCT/US00/20730

9 / 13

FIG. 10A

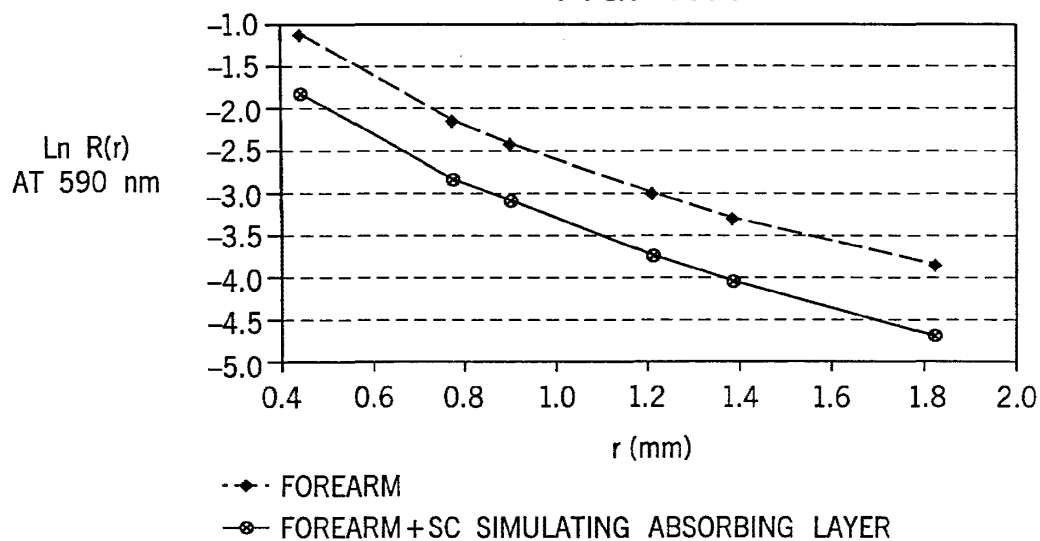
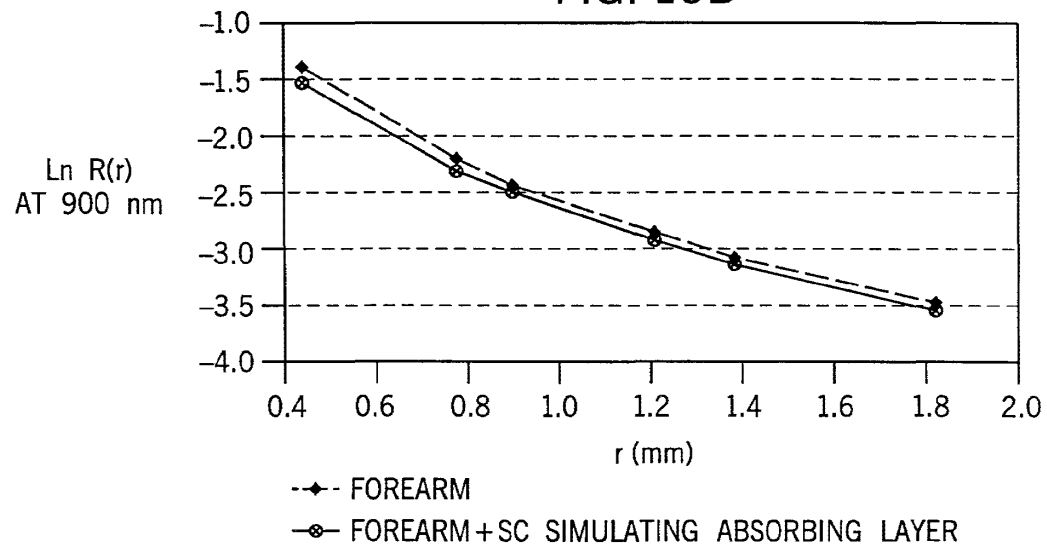


FIG. 10B



WO 01/09589

PCT/US00/20730

10 / 13

FIG. 11A

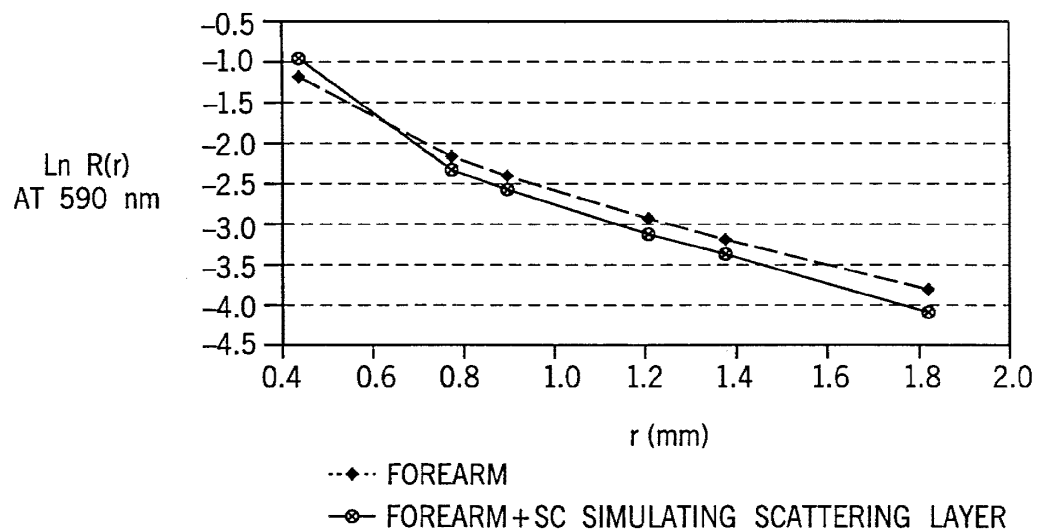
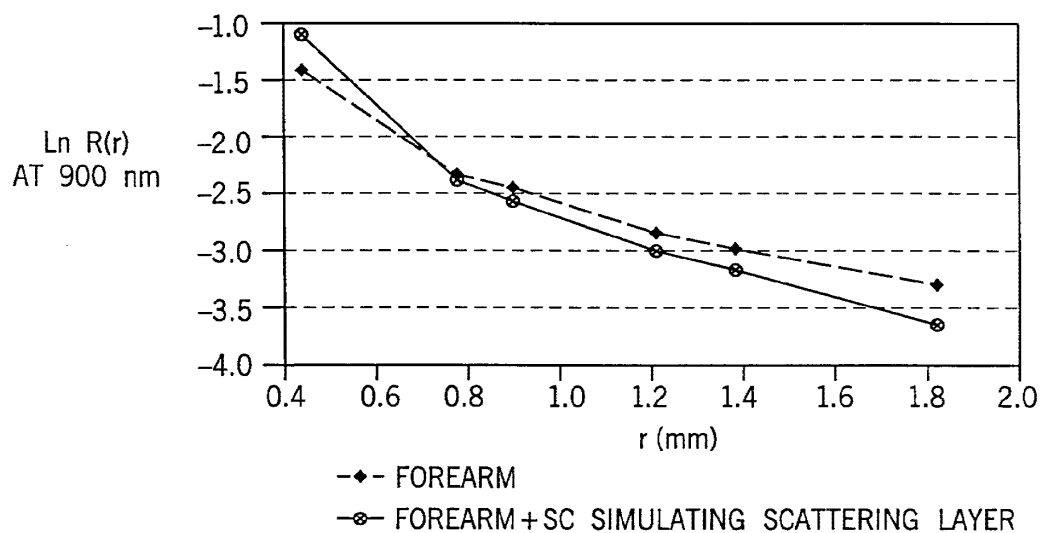


FIG. 11B



WO 01/09589

PCT/US00/20730

11 / 13

FIG. 12A

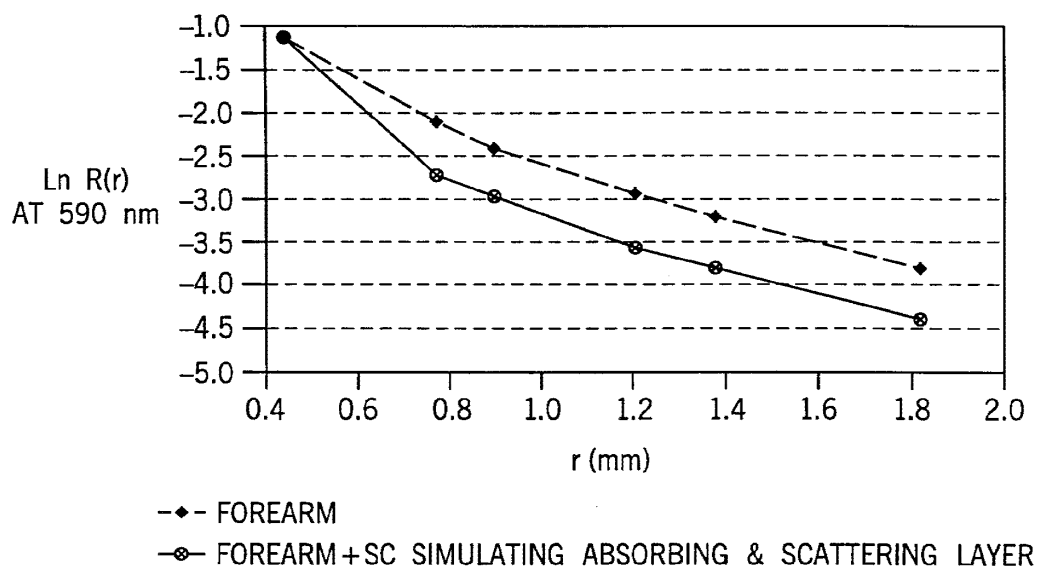
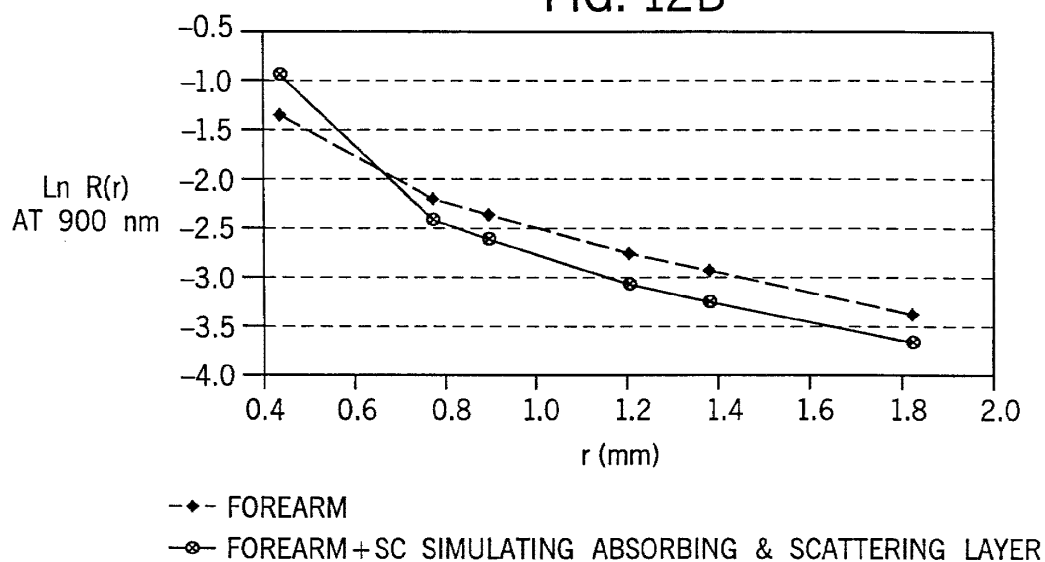


FIG. 12B





WO 01/09589

PCT/US00/20730

12 / 13

FIG. 13A

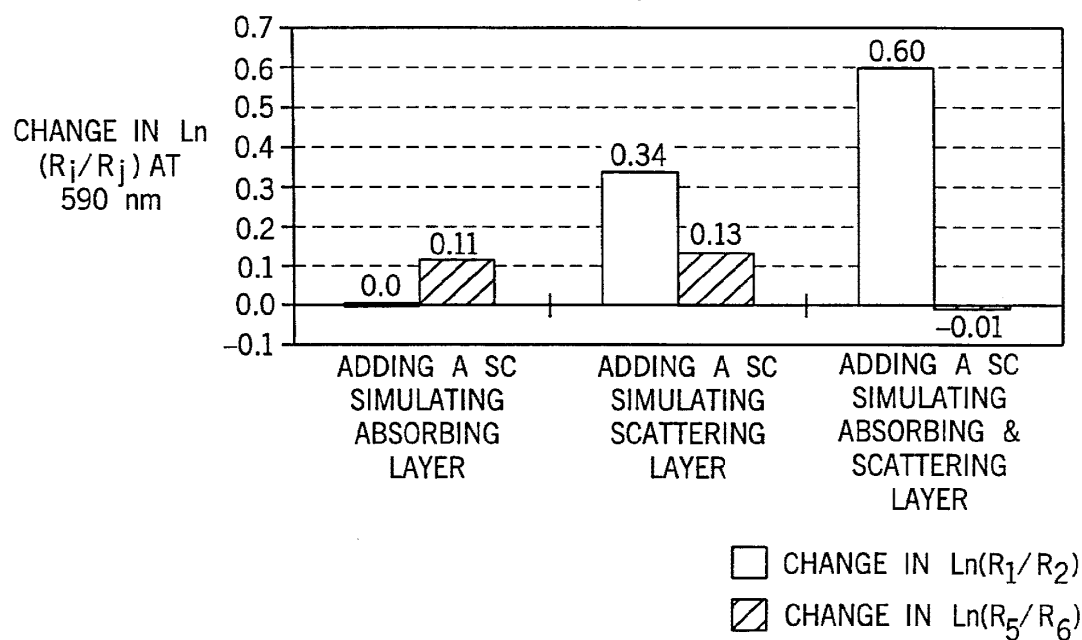
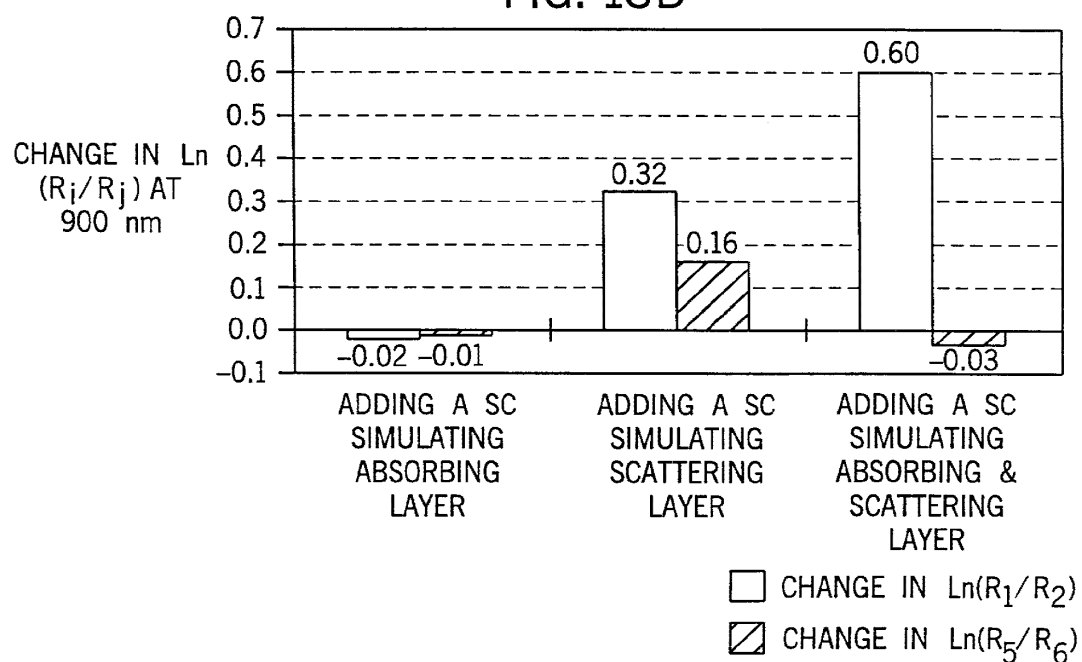


FIG. 13B



WO 01/09589

PCT/US00/20730

13 / 13

FIG. 14A

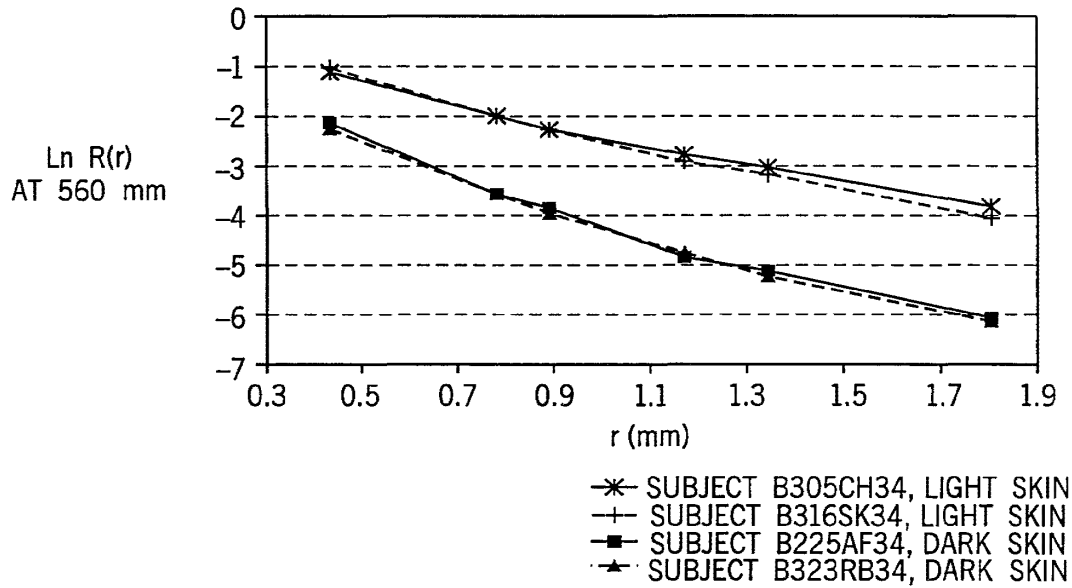
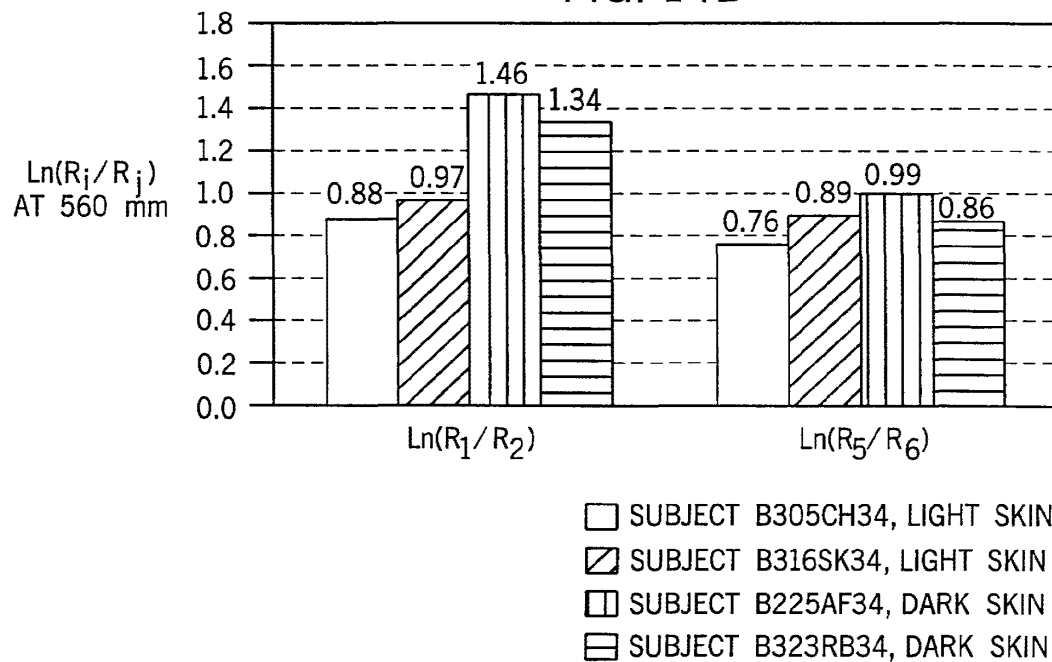


FIG. 14B



## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 00/20730

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
IPC 7 G01N21/49 G01N21/31 A61B5/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols)		
IPC 7 G01N A61B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
EPO-Internal, INSPEC, COMPENDEX		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 843 986 A (MATSUSHITA ELECTRIC WORKS LTD) 27 May 1998 (1998-05-27) column 6-7; figures 1-4,15 column 11 ---	1-73
X	US 5 632 273 A (SUZUKI SUSUMU) 27 May 1997 (1997-05-27) claim 1; figures 1,2,8 ---	1-73
X	US 5 277 181 A (MENDELSON YITZHAK ET AL) 11 January 1994 (1994-01-11) column 2; claims 1,2 ---	1-73
A	US 5 551 422 A (SIMONSEN JAN H ET AL) 3 September 1996 (1996-09-03) figures 4-6 --- -/--	1-73
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents : *A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *&* document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
7 December 2000		14/12/2000
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer  Mason, W

Form PCT/ISA/210 (second sheet) (July 1992)

page 1 of 2

Page 298 of 643

Appx59658

CX-1623

## INTERNATIONAL SEARCH REPORT

Inter. l. Application No

PCT/US 00/20730

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 663 591 A (ISS USA INC ;UNIV ILLINOIS (US)) 19 July 1995 (1995-07-19) figure 2 ----	1-73
A	US 4 655 225 A (DAEHNE CLAUS ET AL) 7 April 1987 (1987-04-07) figure 2 ----	1-73
A	US 5 524 617 A (MANNHEIMER PAUL D) 11 June 1996 (1996-06-11) column 1-2; claim 1; figure 3 ----	1-73
A	US 5 770 454 A (ESSENPREIS MATTHIAS ET AL) 23 June 1998 (1998-06-23) figures 2,8-10 -----	1-73

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

page 2 of 2

Page 299 of 643

Appx59659

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International Application No

PCT/US 00/20730

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0843986 A	27-05-1998	JP 11070101 A	16-03-1999
		CN 1184936 A	17-06-1998
		KR 239095 B	15-01-2000
		US 6016435 A	18-01-2000
US 5632273 A	27-05-1997	JP 7255709 A	09-10-1995
US 5277181 A	11-01-1994	AU 2244592 A	19-07-1993
		WO 9311701 A	24-06-1993
US 5551422 A	03-09-1996	DE 4314835 A	10-11-1994
		DK 136392 A	10-05-1994
		DK 44693 A	10-05-1994
		DK 45793 A	10-05-1994
		AT 136443 T	15-04-1996
		AU 674555 B	02-01-1997
		AU 5416894 A	08-06-1994
		CA 2147639 A	26-05-1994
		WO 9410901 A	26-05-1994
		DE 59302208 D	15-05-1996
		DE 59309645 D	15-07-1999
		DK 659055 T	29-07-1996
		EP 0659055 A	28-06-1995
		EP 0707826 A	24-04-1996
		ES 2086969 T	01-07-1996
		ES 2133643 T	16-09-1999
		FI 951673 A	07-04-1995
		GR 3020063 T	31-08-1996
		HK 201896 A	15-11-1996
		IL 107396 A	18-02-1997
		JP 8502912 T	02-04-1996
		KR 170040 B	20-03-1999
		US 5676143 A	14-10-1997
		NO 951792 A	08-05-1995
		SG 50613 A	20-07-1998
		ZA 9307896 A	25-04-1995
EP 0663591 A	19-07-1995	US 5497769 A	12-03-1996
		US 5492118 A	20-02-1996
		CA 2137878 A	17-06-1995
		JP 8089500 A	09-04-1996
		US 5772587 A	30-06-1998
US 4655225 A	07-04-1987	NONE	
US 5524617 A	11-06-1996	CA 2215163 A	19-09-1996
		EP 0812148 A	17-12-1997
		JP 11501848 T	16-02-1999
		WO 9628085 A	19-09-1996
		US 5746206 A	05-05-1998
US 5770454 A	23-06-1998	DE 4417639 A	23-11-1995
		AT 186395 T	15-11-1999
		AU 2342595 A	18-12-1995
		WO 9532416 A	30-11-1995
		DE 19580537 D	01-04-1999
		DE 59507189 D	09-12-1999
		EP 0760091 A	05-03-1997

Form PCT/ISA/210 (patent family annex) (July 1992)

page 1 of 2

Page 300 of 643

**Appx59660**

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International Application No

PCT/US 00/20730

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5770454 A		JP 10500338 T	13-01-1998

Form PCT/ISA/210 (patent family annex) (July 1992)

page 2 of 2

Page 301 of 643

**Appx59661**

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau(43) International Publication Date  
7 January 2010 (07.01.2010)(10) International Publication Number  
**WO 2010/003134 A2**(51) International Patent Classification:  
*A61B 5/00* (2006.01)(21) International Application Number:  
PCT/US2009/049638(22) International Filing Date:  
2 July 2009 (02.07.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

61/078,207	3 July 2008 (03.07.2008)	US
61/078,228	3 July 2008 (03.07.2008)	US
61/086,060	4 August 2008 (04.08.2008)	US
61/086,063	4 August 2008 (04.08.2008)	US
61/086,108	4 August 2008 (04.08.2008)	US
61/086,057	4 August 2008 (04.08.2008)	US
29/323,408	25 August 2008 (25.08.2008)	US
29/323,409	25 August 2008 (25.08.2008)	US
61/091,732	25 August 2008 (25.08.2008)	US

(71) Applicant (for all designated States except US): **MASI-MO LABORATORIES, INC.** [US/US]; 30 Fairbanks, Suite 100, Irvine, CA 92618 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **KIANI, Massi, Joe E.** [US/US]; 35 Brindisi, Laguna Niguel, CA 92677 (US). **LAMEGO, Marcelo** [BR/US]; 18 Lyra Way, Coto De Caza, CA 92679 (US). **MERRITT, Sean** [US/US]; 22273 Vista Verde Drive, Lake Forest, CA 92630 (US). **DALVI, Cristiano** [BR/US]; 21622 Marguerite Pkwy #6,

Mission Viejo, CA 92692 (US). **VO, Hung** [US/US]; 8801 Mays Ave., Garden Grove, CA 92844 (US). **BRU-INSMA, Johannes** [NL/US]; 27141 Valia, Mission Viejo, CA 92691 (US). **POEZE, Jeroen** [NL/US]; 21622 Marguerite Parkway #342, Mission Viejo, CA 92692 (US). **LESMANA, Ferydan** [ID/US]; 42 New Season, Irvine, CA 92602 (US). **OLSEN, Greg** [US/US]; 18842 Vista Portola, Trabuco Canyon, CA 92679 (US).

(74) Agent: **ALTMAN, Daniel, E.**; Knobbe Martens Olson & Bear, LLP, 2040 Main Street, Fourteenth Floor, Irvine, CA 92614 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: PROTRUSION, HEAT SINK, AND SHIELDING FOR IMPROVING SPECTROSCOPIC MEASUREMENT OF BLOOD CONSTITUENTS

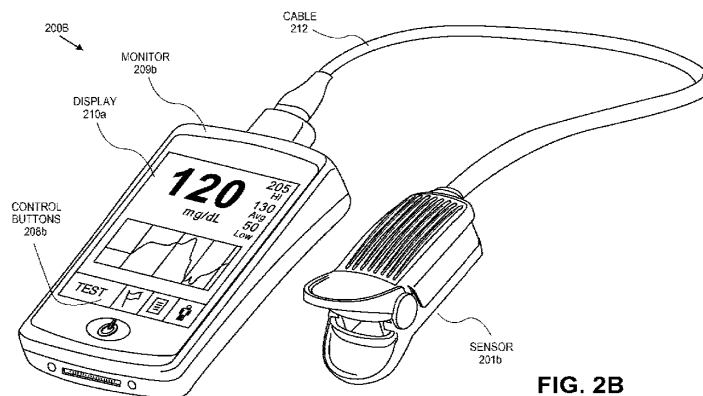


FIG. 2B

(57) Abstract: A noninvasive physiological sensor for measuring one or more physiological parameters of a medical patient can include a bump interposed between a light source and a photodetector. The bump can be placed in contact with body tissue of a patient and thereby reduce a thickness of the body tissue. As a result, an optical pathlength between the light source and the photodetector can be reduced. In addition, the sensor can include a heat sink that can direct heat away from the light source. Moreover, the sensor can include shielding in the optical path between the light source and the photodetector. The shielding can reduce noise received by the photodetector.

**WO 2010/003134 A2** 

---

**Published:**

— *without international search report and to be republished  
upon receipt of that report (Rule 48.2(g))*



WO 2010/003134

PCT/US2009/049638

-1-

**PROTRUSION, HEAT SINK, AND SHIELDING FOR IMPROVING  
SPECTROSCOPIC MEASUREMENT OF BLOOD CONSTITUENTS**

RELATED APPLICATIONS

**[0001]** This application claims the benefit of priority under 35 U.S.C. § 119(e) of the following U.S. Provisional Patent Applications:

<u>App. No.</u>	<u>Filing Date</u>	<u>Title</u>	<u>Attorney Docket</u>
61/086,060	8/4/08	<i>Multi-Stream Data Collection System For Non-Invasive Measurement of Glucose and Other Analytes</i>	MLHUM.002PR
61/086,108	8/4/08	<i>Multi-Stream Sensor Front Ends for Noninvasive Measurement of Glucose and Other Analytes</i>	MLHUM.003PR
61/086,063	8/4/08	<i>Multi-Stream Detector For Noninvasive Measurement Of Glucose And Other Analytes</i>	MLHUM.004PR
61/086,057	8/4/08	<i>Multi-Stream Emitter For Noninvasive Measurement Of Glucose And Other Analytes</i>	MLHUM.005PR
61/078,228	7/3/08	<i>Noise Shielding For A Non-Invasive Device</i>	MLHUM.006PR
61/078,207	7/3/08	<i>Contoured Protrusion for Improving Spectroscopic Measurement of Blood Constituents</i>	MLHUM.007PR
61/091,732	8/25/08	<i>Sensor For Improving Measurement Of Blood Constituents</i>	MLHUM.011PR

**[0002]** This application also claims the benefit of priority under 35 U.S.C. § 120 as a continuation-in-part of the following U.S. Design Patent Applications:

<u>App. No.</u>	<u>Filing Date</u>	<u>Title</u>	<u>Attorney Docket</u>
29/323,409	8/25/08	<i>Patient Monitoring Sensor</i>	MLHUM.009DA
29/323,408	8/25/08	<i>Patient Monitor</i>	MLHUM.010DA

**[0003]** The foregoing applications are hereby incorporated by reference in their entirety.

WO 2010/003134

PCT/US2009/049638

-2-

## BACKGROUND

**[0004]** The standard of care in caregiver environments includes patient monitoring through spectroscopic analysis using, for example, a pulse oximeter. Devices capable of spectroscopic analysis generally include a light source(s) transmitting optical radiation into or reflecting off a measurement site, such as, body tissue carrying pulsing blood. After attenuation by tissue and fluids of the measurement site, a photodetection device(s) detects the attenuated light and outputs a detector signal(s) responsive to the detected attenuated light. A signal processing device(s) process the detector(s) signal(s) and outputs a measurement indicative of a blood constituent of interest, such as glucose, oxygen, met hemoglobin, total hemoglobin, other physiological parameters, or other data or combinations of data useful in determining a state or trend of wellness of a patient.

**[0005]** In noninvasive devices and methods, a sensor is often adapted to position a finger proximate the light source and light detector. For example, noninvasive sensors often include a clothespin-shaped housing that includes a contoured bed conforming generally to the shape of a finger. The contoured bed positions the finger for measurement and attempts to stabilize it.

**[0006]** Unfortunately, this type of contour cannot be ideal, especially for measuring blood constituents like glucose.

## SUMMARY

**[0007]** This disclosure describes embodiments of noninvasive methods, devices, and systems for measuring a blood analyte, such as oxygen, carbon monoxide, methemoglobin, total hemoglobin, glucose, proteins, lipids, a percentage thereof (e.g., saturation) or for measuring many other physiologically relevant patient characteristics. These characteristics can relate, for example, to pulse rate, hydration, trending information and analysis, and the like. In certain embodiments, a noninvasive sensor interfaces with tissue at a measurement site and deforms the tissue in a way that increases signal gain in certain desired wavelengths. In an embodiment, a protrusion can be provided in a finger bed of a noninvasive sensor for a patient's finger. The protrusion can reduce tissue

WO 2010/003134

PCT/US2009/049638

-3-

thickness, thereby sometimes increasing signal gain by tens of times or even more. This protrusion can include different sizes and shapes depending on the tissue site and the desired blood analyte to be measured.

**[0008]** In disclosed embodiments, the protrusion is employed in noninvasive sensors to assist in measuring and detecting various analytes. The disclosed noninvasive sensor can also include, among other things, emitters and detectors positioned to produce multi-stream sensor information. The noninvasive sensor can have different architectures and can include or be coupled to other components, such as a display device, a network interface, and the like. The protrusion can be employed in any type of noninvasive sensor.

**[0009]** In certain embodiments, a noninvasive physiological sensor for measuring one or more physiological parameters of a medical patient can include a bump interposed between a light source and a photodetector. The bump can be placed in contact with body tissue of a patient and thereby reduce a thickness of the body tissue. As a result, an optical pathlength between the light source and the photodetector can be reduced. In addition, the sensor can include a heat sink that can direct heat away from the light source. Moreover, the sensor can include shielding in the optical path between the light source and the photodetector. The shielding can reduce noise received by the photodetector.

**[0010]** In certain embodiments, a noninvasive medical sensor that can detect light attenuated by body tissue of a medical patient can include a sensor housing having an upper shell and a lower shell pivotally connected together, where the upper and lower shells are each shaped to accept body tissue of a medical patient. The sensor can also include one or more emitters disposed in the housing, which can impinge light on the body tissue of the patient. The sensor can also include one or more detectors disposed in the housing, which can receive the light after attenuation by the body tissue of the patient and output one or more intensity signals responsive to the attenuated light. The sensor can also include a tissue thickness adjuster disposed in the housing, which can be positioned such that placement of the body tissue of the patient on the tissue thickness adjuster reduces

WO 2010/003134

PCT/US2009/049638

-4-

a thickness of the body tissue and thereby increases a gain of the one or more intensity signals.

**[0011]** In certain embodiments, a noninvasive physiological sensor for measuring one or more physiological parameters of a medical patient includes a light source and a photodetector that can detect light from said light source after attenuation by body tissue of a medical patient and that can generate a physiological signal responsive to the detected light. The physiological signal can reflect one or more physiological parameters of the medical patient. The sensor can also include a bump interposed between the light source and the photodetector, where the bump protruding from a tissue contacting surface. The bump can reduce a thickness of the body tissue between the light source and the photodetector such that an optical pathlength between the light source and the photodetector is reduced.

**[0012]** In certain embodiments, a noninvasive physiological sensor for measuring one or more physiological parameters of a medical patient can include a light source, one or more photodetectors that can detect light from the light source after attenuation by body tissue of a medical patient and generate a physiological signal responsive to the detected light, and a partially cylindrical lens interposed between the light source and the photodetector.

**[0013]** In certain embodiments, a physiological sensor capable of outputting a signal responsive to a blood analyte present in a monitored patient can include a sensor housing having an optical source that can emit optical radiation on a body tissue of a medical patient. The sensor can also include a heat sink associated with the sensor, which can receive thermal energy from the optical source and release thermal energy outside of the sensor housing. The sensor can also include a plurality of photodetectors each able to detect the optical radiation from the optical source after attenuation by the body tissue of the medical patient and to output a signal responsive to the detected optical radiation, where the signal reflects one or more physiological parameters of the medical patient.

**[0014]** In certain embodiments, a physiological sensor capable of outputting a signal responsive to a blood analyte present in a monitored patient can

WO 2010/003134

PCT/US2009/049638

-5-

include a sensor housing having an optical source that can emit optical radiation on a body tissue of a medical patient. The optical source can have one or more emitters disposed on a submount. The sensor can also include a conductive shield of a medical cable that can be in electrical communication with the submount, such that the conductive shield acts at least in part as a heat sink for the one or more emitters. The sensor can also include a plurality of photodetectors each able to detect the optical radiation from the optical source after attenuation by the body tissue of the medical patient and to output a signal responsive to the detected optical radiation, where the signal reflects one or more physiological parameters of the medical patient.

**[0015]** In certain embodiments, a heat sink of a noninvasive optical medical sensor capable of detecting light attenuated by body tissue can include a heat producing part of an electronic device and a cable in thermal communication with the heat producing part. The cable can include a conductor that can draw heat from the heat producing part.

**[0016]** In certain embodiments, an optical medical sensor that can detect light attenuated by body tissue of a patient can include a sensor housing having a first shell and a second shell pivotally connected together. The first and second shells can each be shaped to accept body tissue of a medical patient. The sensor can also include an emitter disposed in the first shell, which can emit light on the body tissue of the medical patient. The sensor can further include a detector disposed in the second shell, which can receive light attenuated by the body tissue along an optical path. Moreover, the sensor can include shielding disposed between the emitter and the detector, which can include a substantially-transparent, electrically-conductive material in the optical path.

**[0017]** In certain embodiments, a conductive shield that can shield noise interference from a light sensitive detector can include a substantially transparent material and a conductive material disposed on at least a portion of the substantially transparent material. The conductive shield can be positioned between a light source and a light detector such that at least some light from said light source passes through said conductive shield and impinges on the light detector.

WO 2010/003134

PCT/US2009/049638

-6-

**[0018]** In certain embodiments, a system for shielding one or more photocommunicative devices can include an emitter that can emit optical radiation, a detector, and a shielding device disposed between the emitter and the detector. The shielding device can include a substantially-transparent, electrically-conductive material. The shielding device can pass at least a portion of the optical radiation to the detector and reduce a noise received by the detector.

**[0019]** In certain embodiments, an optical medical sensor that can detect light attenuated by body tissue of a patient can include an emitter that can emit optical radiation, a detector, and a noise shield having: a substantially-transparent, electrically-conductive material that can reduce noise received by the detector, and a window in the substantially-transparent, electrically-conductive material. The window can pass at least a portion of the optical radiation to the detector.

**[0020]** For purposes of summarizing the disclosure, certain aspects, advantages and novel features of the inventions have been described herein. It is to be understood that not necessarily all such advantages can be achieved in accordance with any particular embodiment of the inventions disclosed herein. Thus, the inventions disclosed herein can be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other advantages as can be taught or suggested herein.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0021]** Throughout the drawings, reference numbers can be re-used to indicate correspondence between referenced elements. The drawings are provided to illustrate embodiments of the inventions described herein and not to limit the scope thereof.

**[0022]** FIGURE 1 illustrates a block diagram of an example data collection system capable of noninvasively measuring one or more blood analytes in a monitored patient, according to an embodiment of the disclosure;

WO 2010/003134

PCT/US2009/049638

-7-

**[0023]** FIGURES 2A – 2D illustrate an exemplary handheld monitor and an exemplary noninvasive optical sensor of the patient monitoring system of Figure 1, according to embodiments of the disclosure;

**[0024]** FIGURES 3A – 3C illustrate side and perspective views of an exemplary noninvasive sensor housing including a finger bed protrusion and heat sink, according to an embodiment of the disclosure;

**[0025]** FIGURE 3D illustrates a side view of another example noninvasive sensor housing including a heat sink, according to an embodiment of the disclosure;

**[0026]** FIGURE 3E illustrates a perspective view of an example noninvasive sensor detector shell including example detectors, according to an embodiment of the disclosure;

**[0027]** FIGURE 3F illustrates a side view of an example noninvasive sensor housing including a finger bed protrusion and heat sink, according to an embodiment of the disclosure;

**[0028]** FIGURES 4A through 4C illustrate top elevation, side and top perspective views of an example protrusion, according to an embodiment of the disclosure;

**[0029]** FIGURE 5 illustrates an example graph depicting possible effects of a protrusion on light transmittance, according to an embodiment of the disclosure;

**[0030]** FIGURES 6A through 6D illustrate perspective, front elevation, side and top views of another example protrusion, according to an embodiment of the disclosure;

**[0031]** FIGURE 6E illustrates an example sensor incorporating the protrusion of FIGURES 6A through 6D, according to an embodiment of the disclosure;

**[0032]** FIGURES 7A through 7B illustrate example arrangements of conductive glass that may be employed in the system of FIGURE 1, according to embodiments of the disclosure.

**[0033]** FIGURES 8A through 8D illustrate an example top elevation view, side views, and a bottom elevation view of the conductive glass that may be employed in the system of FIGURE 1, according to embodiments of the disclosure;

WO 2010/003134

PCT/US2009/049638

-8-

**[0034]** FIGURE 9 shows example comparative results obtained by an embodiment of a sensor;

**[0035]** FIGURES 10A and 10B illustrate comparative noise floors of various embodiments of the present disclosure;

**[0036]** FIGURE 11 illustrates a block diagram of some of the components that may include an embodiment of a sensor, according to an embodiment of the disclosure;

**[0037]** FIGURE 12 illustrates an example detector portion that may be employed in an embodiment of a sensor, according to an embodiment of the disclosure;

**[0038]** FIGURE 13 illustrates an example multi-stream operation of the system of FIGURE 1, according to an embodiment of the disclosure;

**[0039]** FIGURE 14A illustrates another example detector portion having a partially cylindrical protrusion that can be employed in an embodiment of a sensor, according to an embodiment of the disclosure;

**[0040]** FIGURE 14B depicts a front elevation view of the partially cylindrical protrusion of FIGURE 14A;

**[0041]** FIGURES 14C through 14E illustrate embodiments of a detector submount;

**[0042]** FIGURES 14F through 14H illustrate embodiment of portions of a detector shell;

**[0043]** FIGURE 14I illustrates a cutaway view of an embodiment of a sensor;

**[0044]** FIGURES 15A through 15F illustrate embodiments of sensors that include heat sink features;

**[0045]** FIGURES 15G and 15H illustrate embodiments of connector features that can be used with any of the sensors described herein;

**[0046]** FIGURES 16A and 16B illustrate embodiments of disposable optical sensors; and

**[0047]** FIGURE 17 illustrates an exploded view of certain components of an example sensor.



WO 2010/003134

PCT/US2009/049638

-9-

## DETAILED DESCRIPTION

**[0048]** The present disclosure generally relates to non-invasive medical devices. In an embodiment, a physiological sensor includes a detector housing that can be coupled to a measurement site, such as a patient's finger. The sensor housing can include a curved bed that can generally conform to the shape of the measurement site. In addition, the curved bed can include a protrusion shaped to increase an amount of light radiation from the measurement site. In an embodiment, the protrusion is used to thin out the measurement site. This allows the light radiation to pass through less tissue, and accordingly is attenuated less. In an embodiment, the protrusion can be used to increase the area from which attenuated light can be measured. In an embodiment, this is done through the use of a lens which collects attenuated light exiting the measurement site and focuses onto one or more detectors. The protrusion can advantageously include plastic, including a hard opaque plastic, such as a black or other colored plastic, helpful in reducing light noise. In an embodiment, such light noise includes light that would otherwise be detected at a photodetector that has not been attenuated by tissue of the measurement site of a patient sufficient to cause the light to adequately included information indicative of one or more physiological parameters of the patient. Such light noise includes light piping.

**[0049]** In an embodiment, the protrusion can be formed from the curved bed, or can be a separate component that is positionable with respect to the bed. In an embodiment, a lens made from any appropriate material is used as the protrusion. The protrusion can be convex in shape. The protrusion can also be sized and shaped to conform the measurement site into a flat or relatively flat surface. The protrusion can also be sized to conform the measurement site into a rounded surface, such as, for example, a concave or convex surface. The protrusion can include a cylindrical or partially cylindrical shape. The protrusion can be sized or shaped differently for different types of patients, such as an adult, child, or infant. The protrusion can also be sized or shaped differently for different measurement sites, including, for example, a finger, toe, hand, foot, ear, forehead,

WO 2010/003134

PCT/US2009/049638

-10-

or the like. The protrusion can thus be helpful in any type of noninvasive sensor. The external surface of the protrusion can include one or more openings or windows. The openings can be made from glass to allow attenuated light from a measurement site, such as a finger, to pass through to one or more detectors. Alternatively, some of all of the protrusion can be a lens, such as a partially cylindrical lens.

**[0050]** The sensor can also include a shielding, such as a metal enclosure as described below or embedded within the protrusion to reduce noise. The shielding can be constructed from a conductive material, such as copper, in the form of a metal cage or enclosure, such as a box. The shielding can include a second set of one or more openings or windows. The second set of openings can be made from glass and allow light that has passed through the first set of windows of the external surface of the protrusion to pass through to one or more detectors that can be enclosed, for example, as described below.

**[0051]** In various embodiments, the shielding can include any substantially transparent, conductive material placed in the optical path between an emitter and a detector. The shielding can be constructed from a transparent material, such as glass, plastic, and the like. The shielding can have an electrically conductive material or coating that is at least partially transparent. The electrically conductive coating can be located on one or both sides of the shielding, or within the body of the shielding. In addition, the electrically conductive coating can be uniformly spread over the shielding or may be patterned. Furthermore, the coating can have a uniform or varying thickness to increase or optimize its shielding effect. The shielding can be helpful in virtually any type of noninvasive sensor that employs spectroscopy.

**[0052]** In an embodiment, the sensor can also include a heat sink. In an embodiment, the heat sink can include a shape that is functional in its ability to dissipate excess heat and aesthetically pleasing to the wearer. For example, the heat sink can be configured in a shape that maximizes surface area to allow for greater dissipation of heat. In an embodiment, the heat sink includes a metalized plastic, such as plastic including carbon and aluminum to allow for improved thermal

WO 2010/003134

PCT/US2009/049638

-11-

conductivity and diffusivity. In an embodiment, the heat sink can advantageously be inexpensively molded into desired shapes and configurations for aesthetic and functional purposes. For example, the shape of the heat sink can be a generally curved surface and include one or more fins, undulations, grooves or channels, or combs.

**[0053]** In the present disclosure, a sensor can measure various blood analytes noninvasively using multi-stream spectroscopy. In an embodiment, the multi-stream spectroscopy can employ visible, infrared and near infrared wavelengths. As disclosed herein, the sensor is capable of noninvasively measuring blood analytes or percentages thereof (e.g., saturation) based on various combinations of features and components.

**[0054]** The sensor can include photocommunicative components, such as an emitter, a detector, and other components. The emitter can include a plurality of sets of optical sources that, in an embodiment, are arranged together as a point source. The various optical sources can emit a sequence of optical radiation pulses at different wavelengths towards a measurement site, such as a patient's finger. Detectors can then detect optical radiation from the measurement site. The optical sources and optical radiation detectors can operate at any appropriate wavelength, including, as discussed herein, infrared, near infrared, visible light, and ultraviolet. In addition, the optical sources and optical radiation detectors can operate at any appropriate wavelength, and such modifications to the embodiments desirable to operate at any such wavelength will be apparent to those skilled in the art. In certain embodiments, multiple detectors are employed and arranged in a spatial geometry. This spatial geometry provides a diversity of path lengths among at least some of the detectors and allows for multiple bulk and pulsatile measurements that are robust. Each of the detectors can provide a respective output stream based on the detected optical radiation, or a sum of output streams can be provided from multiple detectors. In some embodiments, the sensor can also include other components, such as one or more heat sinks and one or more thermistors.

WO 2010/003134

PCT/US2009/049638

-12-

**[0055]** The sensor can be coupled to one or more monitors that process and/or display the sensor's output. The monitors can include various components, such as a sensor front end, a signal processor, a display, etc.

**[0056]** The sensor can be integrated with a monitor, for example, into a handheld unit including the sensor, a display and user controls. In other embodiments, the sensor can communicate with one or more processing devices. The communication can be via wire(s), cable(s), flex circuit(s), wireless technologies, or other suitable analog or digital communication methodologies and devices to perform those methodologies. Many of the foregoing arrangements allow the sensor to be attached to the measurement site while the device is attached elsewhere on a patient, such as the patient's arm, or placed at a location near the patient, such as a bed, shelf or table. The sensor or monitor can also provide outputs to a storage device or network interface.

**[0057]** Reference will now be made to the Figures to discuss embodiments of the present disclosure.

**[0058]** **FIGURE 1** illustrates an example of a data collection system 100. In certain embodiments, the data collection system 100 noninvasively measure a blood analyte, such as oxygen, carbon monoxide, methemoglobin, total hemoglobin, glucose, proteins, lipids, a percentage thereof (e.g., saturation) or for measuring many other physiologically relevant patient characteristics. The system 100 can also measure additional blood analytes and/or other physiological parameters useful in determining a state or trend of wellness of a patient.

**[0059]** The data collection system 100 can be capable of measuring optical radiation from the measurement site. For example, in some embodiments, the data collection system 100 can employ photodiodes defined in terms of area. In an embodiment, the area is from about 1 mm<sup>2</sup> – 5 mm<sup>2</sup> (or higher) that are capable of detecting about 100 nanoamps (nA) or less of current resulting from measured light at full scale. In addition to having its ordinary meaning, the phrase “at full scale” can mean light saturation of a photodiode amplifier (not shown). Of course, as would be understood by a person of skill in the art from the present disclosure,

WO 2010/003134

PCT/US2009/049638

-13-

various other sizes and types of photodiodes can be used with the embodiments of the present disclosure.

**[0060]** The data collection system 100 can measure a range of approximately about 2 nA to about 100 nA full scale. The data collection system 100 can also include sensor front-ends that are capable of processing and amplifying current from the detector(s) at signal-to-noise ratios (SNRs) of about 100 decibels (dB) or more, such as about 120 dB in order to measure various desired analytes. The data collection system 100 can operate with a lower SNR if less accuracy is desired for an analyte like glucose.

**[0061]** The data collection system 100 can measure analyte concentrations, including glucose, at least in part by detecting light attenuated by a measurement site 102. The measurement site 102 can be any location on a patient's body, such as a finger, foot, ear lobe, or the like. For convenience, this disclosure is described primarily in the context of a finger measurement site 102. However, the features of the embodiments disclosed herein can be used with other measurement sites 102.

**[0062]** In the depicted embodiment, the system 100 includes an optional tissue thickness adjuster or tissue shaper 105, which can include one or more protrusions, bumps, lenses, or other suitable tissue-shaping mechanisms. In certain embodiments, the tissue shaper 105 is a flat or substantially flat surface that can be positioned proximate the measurement site 102 and that can apply sufficient pressure to cause the tissue of the measurement site 102 to be flat or substantially flat. In other embodiments, the tissue shaper 105 is a convex or substantially convex surface with respect to the measurement site 102. Many other configurations of the tissue shaper 105 are possible. Advantageously, in certain embodiments, the tissue shaper 105 reduces thickness of the measurement site 102 while preventing or reducing occlusion at the measurement site 102. Reducing thickness of the site can advantageously reduce the amount of attenuation of the light because there is less tissue through which the light must travel. Shaping the tissue into a convex (or alternatively concave) surface can also provide more surface area from which light can be detected.

WO 2010/003134

PCT/US2009/049638

-14-

**[0063]** The embodiment of the data collection system 100 shown also includes an optional noise shield 103. In an embodiment, the noise shield 103 can be advantageously adapted to reduce electromagnetic noise while increasing the transmittance of light from the measurement site 102 to one or more detectors 106 (described below). For example, the noise shield 103 can advantageously include a conductive coated glass or metal grid electrically communicating with one or more other shields of the sensor 101. In an embodiment where the noise shield 103 includes conductive coated glass, the coating can advantageously include indium tin oxide. In an embodiment, the indium tin oxide includes a surface resistivity ranging from approximately from 30 ohms per square inch to 500 ohms per square inch. In an embodiment, the resistivity is approximately 30, 200, or 500 ohms per square inch. As would be understood by a person of skill in the art from the present disclosure, other resistivities can also be used which are less than 30 ohms or more than 500 ohms. Other conductive materials transparent or substantially transparent to light can be used instead.

**[0064]** In some embodiments, the measurement site 102 is somewhere along a non-dominant arm or a non-dominant hand, e.g., a right-handed person's left arm or left hand. In some patients, the non-dominant arm or hand can have less musculature and higher fat content, which can result in less water content in that tissue of the patient. Tissue having less water content can provide less interference with the particular wavelengths that are absorbed in a useful manner by blood analytes like glucose. Accordingly, in some embodiments, the data collection system 100 can be used on a person's non-dominant hand or arm.

**[0065]** The data collection system 100 can include a sensor 101 (or multiple sensors) that is coupled to a processing device or physiological monitor 109. In an embodiment, the sensor 101 and the monitor 109 are integrated together into a single unit. In another embodiment, the sensor 101 and the monitor 109 are separate from each other and communicate one with another in any suitable manner, such as via a wired or wireless connection. The sensor 101 and monitor 109 can be attachable and detachable from each other for the convenience of the

WO 2010/003134

PCT/US2009/049638

-15-

user or caregiver, for ease of storage, sterility issues, or the like. The sensor 101 and the monitor 109 will now be further described.

**[0066]** In the depicted embodiment shown in **FIGURE 1**, the sensor 101 includes an emitter 104, a tissue shaper 105, a set of detectors 106, and a front-end interface 108. The emitter 104 can serve as the source of optical radiation transmitted towards measurement site 102. As will be described in further detail below, the emitter 104 can include one or more sources of optical radiation, such as LEDs, laser diodes, incandescent bulbs with appropriate frequency-selective filters, combinations of the same, or the like. In an embodiment, the emitter 104 includes sets of optical sources that are capable of emitting visible and near-infrared optical radiation.

**[0067]** In some embodiments, the emitter 104 is used as a point optical source, and thus, the one or more optical sources of the emitter 104 can be located within a close distance to each other, such as within about a 2 mm to about 4 mm. The emitters 104 can be arranged in an array, such as is described in U.S. Publication No. 2006/0211924, filed Sept. 21, 2006, titled "Multiple Wavelength Sensor Emitters," the disclosure of which is hereby incorporated by reference in its entirety. In particular, the emitters 104 can be arranged at least in part as described in paragraphs [0061] through [0068] of the aforementioned publication, which paragraphs are hereby incorporated specifically by reference. Other relative spatial relationships can be used to arrange the emitters 104.

**[0068]** For analytes like glucose, currently available non-invasive techniques often attempt to employ light near the water absorbance minima at or about 1600 nm. Typically, these devices and methods employ a single wavelength or single band of wavelengths at or about 1600 nm. However, to date, these techniques have been unable to adequately consistently measure analytes like glucose based on spectroscopy.

**[0069]** In contrast, the emitter 104 of the data collection system 100 can emit, in certain embodiments, combinations of optical radiation in various bands of interest. For example, in some embodiments, for analytes like glucose, the emitter 104 can emit optical radiation at three (3) or more wavelengths between about 1600

WO 2010/003134

PCT/US2009/049638

-16-

nm to about 1700 nm. In particular, the emitter 104 can emit optical radiation at or about 1610 nm, about 1640 nm, and about 1665 nm. In some circumstances, the use of three wavelengths within about 1600 nm to about 1700 nm enable sufficient SNRs of about 100 dB, which can result in a measurement accuracy of about 20 mg/DL or better for analytes like glucose.

**[0070]** In other embodiments, the emitter 104 can use two (2) wavelengths within about 1600 nm to about 1700 nm to advantageously enable SNRs of about 85 dB, which can result in a measurement accuracy of about 25-30 mg/DL or better for analytes like glucose. Furthermore, in some embodiments, the emitter 104 can emit light at wavelengths above about 1670 nm. Measurements at these wavelengths can be advantageously used to compensate or confirm the contribution of protein, water, and other non-hemoglobin species exhibited in measurements for analytes like glucose conducted between about 1600 nm and about 1700 nm. Of course, other wavelengths and combinations of wavelengths can be used to measure analytes and/or to distinguish other types of tissue, fluids, tissue properties, fluid properties, combinations of the same or the like.

**[0071]** For example, the emitter 104 can emit optical radiation across other spectra for other analytes. In particular, the emitter 104 can employ light wavelengths to measure various blood analytes or percentages (e.g., saturation) thereof. For example, in one embodiment, the emitter 104 can emit optical radiation in the form of pulses at wavelengths about 905 nm, about 1050 nm, about 1200 nm, about 1300 nm, about 1330 nm, about 1610 nm, about 1640 nm, and about 1665 nm. In another embodiment, the emitter 104 can emit optical radiation ranging from about 860 nm to about 950 nm, about 950 nm to about 1100 nm, about 1100 nm to about 1270 nm, about 1250 nm to about 1350 nm, about 1300 nm to about 1360 nm, and about 1590 nm to about 1700 nm. Of course, the emitter 104 can transmit any of a variety of wavelengths of visible or near-infrared optical radiation.

**[0072]** Due to the different responses of analytes to the different wavelengths, certain embodiments of the data collection system 100 can advantageously use the measurements at these different wavelengths to improve the accuracy of measurements. For example, the measurements of water from



WO 2010/003134

PCT/US2009/049638

-17-

visible and infrared light can be used to compensate for water absorbance that is exhibited in the near-infrared wavelengths.

**[0073]** As briefly described above, the emitter 104 can include sets of light-emitting diodes (LEDs) as its optical source. The emitter 104 can use one or more top-emitting LEDs. In particular, in some embodiments, the emitter 104 can include top-emitting LEDs emitting light at about 850 nm to 1350 nm.

**[0074]** The emitter 104 can also use super luminescent LEDs (SLEDs) or side-emitting LEDs. In some embodiments, the emitter 104 can employ SLEDs or side-emitting LEDs to emit optical radiation at about 1600 nm to about 1800 nm. Emitter 104 can use SLEDs or side-emitting LEDs to transmit near infrared optical radiation because these types of sources can transmit at high power or relatively high power, e.g., about 40 mW to about 100 mW. This higher power capability can be useful to compensate or overcome the greater attenuation of these wavelengths of light in tissue and water. For example, the higher power emission can effectively compensate and/or normalize the absorption signal for light in the mentioned wavelengths to be similar in amplitude and/or effect as other wavelengths that can be detected by one or more photodetectors after absorption. Alternatively, the emitter 104 can use other types of sources of optical radiation, such as a laser diode, to emit near-infrared light into the measurement site 102.

**[0075]** In addition, in some embodiments, in order to assist in achieving a comparative balance of desired power output between the LEDs, some of the LEDs in the emitter 104 can have a filter or covering that reduces and/or cleans the optical radiation from particular LEDs or groups of LEDs. For example, since some wavelengths of light can penetrate through tissue relatively well, LEDs, such as some or all of the top-emitting LEDs can use a filter or covering, such as a cap or painted dye. This can be useful in allowing the emitter 104 to use LEDs with a higher output and/or to equalize intensity of LEDs.

**[0076]** The data collection system 100 also includes a driver 111 that drives the emitter 104. The driver 111 can be a circuit or the like that is controlled by the monitor 109. For example, the driver 111 can provide pulses of current to the emitter 104. In an embodiment, the driver 111 drives the emitter 104 in a

WO 2010/003134

PCT/US2009/049638

-18-

progressive fashion, such as in an alternating manner. The driver 111 can drive the emitter 104 with a series of pulses of about 1 milliwatt (mW) for some wavelengths that can penetrate tissue relatively well and from about 40 mW to about 100 mW for other wavelengths that tend to be significantly absorbed in tissue. A wide variety of other driving powers and driving methodologies can be used in various embodiments.

**[0077]** The driver 111 can be synchronized with other parts of the sensor 101 and can minimize or reduce jitter in the timing of pulses of optical radiation emitted from the emitter 104. In some embodiments, the driver 111 is capable of driving the emitter 104 to emit optical radiation in a pattern that varies by less than about 10 parts-per-million.

**[0078]** The detectors 106 capture and measure light from the measurement site 102. For example, the detectors 106 can capture and measure light transmitted from the emitter 104 that has been attenuated or reflected from the tissue in the measurement site 102. The detectors 106 can output a detector signal 107 responsive to the light captured or measured. The detectors 106 can be implemented using one or more photodiodes, phototransistors, or the like.

**[0079]** In addition, the detectors 106 can be arranged with a spatial configuration to provide a variation of path lengths among at least some of the detectors 106. That is, some of the detectors 106 can have the substantially, or from the perspective of the processing algorithm, effectively, the same path length from the emitter 104. However, according to an embodiment, at least some of the detectors 106 can have a different path length from the emitter 104 relative to other of the detectors 106. Variations in path lengths can be helpful in allowing the use of a bulk signal stream from the detectors 106.

**[0080]** The front end interface 108 provides an interface that adapts the output of the detectors 106, which is responsive to desired physiological parameters. For example, the front end interface 108 can adapt a signal 107 received from one or more of the detectors 106 into a form that can be processed by the monitor 109, for example, by a signal processor 110 in the monitor 109. The front end interface 108 can have its components assembled in the sensor 101, in

WO 2010/003134

PCT/US2009/049638

-19-

the monitor 109, in connecting cabling (if used), combinations of the same, or the like. The location of the front end interface 108 can be chosen based on various factors including space desired for components, desired noise reductions or limits, desired heat reductions or limits, and the like.

**[0081]** The front end interface 108 can be coupled to the detectors 106 and to the signal processor 110 using a bus, wire, electrical or optical cable, flex circuit, or some other form of signal connection. The front end interface 108 can also be at least partially integrated with various components, such as the detectors 106. For example, the front end interface 108 can include one or more integrated circuits that are on the same circuit board as the detectors 106. Other configurations can also be used.

**[0082]** The front end interface 108 can be implemented using one or more amplifiers, such as transimpedance amplifiers, that are coupled to one or more analog to digital converters (ADCs) (which can be in the monitor 109), such as a sigma-delta ADC. A transimpedance-based front end interface 108 can employ single-ended circuitry, differential circuitry, and/or a hybrid configuration. A transimpedance-based front end interface 108 can be useful for its sampling rate capability and freedom in modulation/demodulation algorithms. For example, this type of front end interface 108 can advantageously facilitate the sampling of the ADCs being synchronized with the pulses emitted from the emitter 104.

**[0083]** The ADC or ADCs can provide one or more outputs into multiple channels of digital information for processing by the signal processor 110 of the monitor 109. Each channel can correspond to a signal output from a detector 106.

**[0084]** In some embodiments, a programmable gain amplifier (PGA) can be used in combination with a transimpedance-based front end interface 108. For example, the output of a transimpedance-based front end interface 108 can be output to a PGA that is coupled with an ADC in the monitor 109. A PGA can be useful in order to provide another level of amplification and control of the stream of signals from the detectors 106. Alternatively, the PGA and ADC components can be integrated with the transimpedance-based front end interface 108 in the sensor 101.

WO 2010/003134

PCT/US2009/049638

-20-

**[0085]** In another embodiment, the front end interface 108 can be implemented using switched-capacitor circuits. A switched-capacitor-based front end interface 108 can be useful for, in certain embodiments, its resistor-free design and analog averaging properties. In addition, a switched-capacitor-based front end interface 108 can be useful because it can provide a digital signal to the signal processor 110 in the monitor 109.

**[0086]** As shown in **FIGURE 1**, the monitor 109 can include the signal processor 110 and a user interface, such as a display 112. The monitor 109 can also include optional outputs alone or in combination with the display 112, such as a storage device 114 and a network interface 116. In an embodiment, the signal processor 110 includes processing logic that determines measurements for desired analytes, such as glucose, based on the signals received from the detectors 106. The signal processor 110 can be implemented using one or more microprocessors or subprocessors (e.g., cores), digital signal processors, application specific integrated circuits (ASICs), field programmable gate arrays (FPGAs), combinations of the same, and the like.

**[0087]** The signal processor 110 can provide various signals that control the operation of the sensor 101. For example, the signal processor 110 can provide an emitter control signal to the driver 111. This control signal can be useful in order to synchronize, minimize, or reduce jitter in the timing of pulses emitted from the emitter 104. Accordingly, this control signal can be useful in order to cause optical radiation pulses emitted from the emitter 104 to follow a precise timing and consistent pattern. For example, when a transimpedance-based front end interface 108 is used, the control signal from the signal processor 110 can provide synchronization with the ADC in order to avoid aliasing, cross-talk, and the like. As also shown, an optional memory 113 can be included in the front-end interface 108 and/or in the signal processor 110. This memory 113 can serve as a buffer or storage location for the front-end interface 108 and/or the signal processor 110, among other uses.

**[0088]** The user interface 112 can provide an output, e.g., on a display, for presentation to a user of the data collection system 100. The user interface 112 can

WO 2010/003134

PCT/US2009/049638

-21-

be implemented as a touch-screen display, an LCD display, an organic LED display, or the like. In addition, the user interface 112 can be manipulated to allow for measurement on the non-dominant side of patient. For example, the user interface 112 can include a flip screen, a screen that can be moved from one side to another on the monitor 109, or can include an ability to reorient its display indicia responsive to user input or device orientation. In alternative embodiments, the data collection system 100 can be provided without a user interface 112 and can simply provide an output signal to a separate display or system.

**[0089]** A storage device 114 and a network interface 116 represent other optional output connections that can be included in the monitor 109. The storage device 114 can include any computer-readable medium, such as a memory device, hard disk storage, EEPROM, flash drive, or the like. The various software and/or firmware applications can be stored in the storage device 114, which can be executed by the signal processor 110 or another processor of the monitor 109. The network interface 116 can be a serial bus port (RS-232/RS-485), a Universal Serial Bus (USB) port, an Ethernet port, a wireless interface (e.g., WiFi such as any 802.1x interface, including an internal wireless card), or other suitable communication device(s) that allows the monitor 109 to communicate and share data with other devices. The monitor 109 can also include various other components not shown, such as a microprocessor, graphics processor, or controller to output the user interface 112, to control data communications, to compute data trending, or to perform other operations.

**[0090]** Although not shown in the depicted embodiment, the data collection system 100 can include various other components or can be configured in different ways. For example, the sensor 101 can have both the emitter 104 and detectors 106 on the same side of the measurement site 102 and use reflectance to measure analytes. The data collection system 100 can also include a sensor that measures the power of light emitted from the emitter 104.

**[0091]** **FIGURES 2A** through **2D** illustrate example monitoring devices 200 in which the data collection system 100 can be housed. Advantageously, in certain embodiments, some or all of the example monitoring devices 200 shown can have a

WO 2010/003134

PCT/US2009/049638

-22-

shape and size that allows a user to operate it with a single hand or attach it, for example, to a patient's body or limb. Although several examples are shown, many other monitoring device configurations can be used to house the data collection system 100. In addition, certain of the features of the monitoring devices 200 shown in FIGURES 2A through 2D can be combined with features of the other monitoring devices 200 shown.

**[0092]** Referring specifically to **FIGURE 2A**, an example monitoring device 200A is shown, in which a sensor 201a and a monitor 209a are integrated into a single unit. The monitoring device 200A shown is a handheld or portable device that can measure glucose and other analytes in a patient's finger. The sensor 201a includes an emitter shell 204a and a detector shell 206a. The depicted embodiment of the monitoring device 200A also includes various control buttons 208a and a display 210a.

**[0093]** The sensor 201a can be constructed of white material used for reflective purposes (such as white silicone or plastic), which can increase usable signal at the detector 106 by forcing light back into the sensor 201a. Pads in the emitter shell 204a and the detector shell 206a can contain separated windows to prevent or reduce mixing of light signals, for example, from distinct quadrants on a patient's finger. In addition, these pads can be made of a relatively soft material, such as a gel or foam, in order to conform to the shape, for example, of a patient's finger. The emitter shell 204a and the detector shell 206a can also include absorbing black or grey material portions to prevent or reduce ambient light from entering into the sensor 201a.

**[0094]** In some embodiments, some or all portions of the emitter shell 204a and/or detector shell 206a can be detachable and/or disposable. For example, some or all portions of the shells 204a and 206a can be removable pieces. The removability of the shells 204a and 206a can be useful for sanitary purposes or for sizing the sensor 201a to different patients. The monitor 209a can include a fitting, slot, magnet, or other connecting mechanism to allow the sensor 201c to be removably attached to the monitor 209a.

WO 2010/003134

PCT/US2009/049638

-23-

**[0095]** The monitoring device 200a also includes optional control buttons 208a and a display 210a that can allow the user to control the operation of the device. For example, a user can operate the control buttons 208a to view one or more measurements of various analytes, such as glucose. In addition, the user can operate the control buttons 208a to view other forms of information, such as graphs, histograms, measurement data, trend measurement data, parameter combination views, wellness indications, and the like. Many parameters, trends, alarms and parameter displays could be output to the display 210a, such as those that are commercially available through a wide variety of noninvasive monitoring devices from Masimo<sup>®</sup> Corporation of Irvine, California.

**[0096]** Furthermore, the controls 208a and/or display 210a can provide functionality for the user to manipulate settings of the monitoring device 200a, such as alarm settings, emitter settings, detector settings, and the like. The monitoring device 200a can employ any of a variety of user interface designs, such as frames, menus, touch-screens, and any type of button.

**[0097] FIGURE 2B** illustrates another example of a monitoring device 200B. In the depicted embodiment, the monitoring device 200B includes a finger clip sensor 201b connected to a monitor 209b via a cable 212. In the embodiment shown, the monitor 209b includes a display 210b, control buttons 208b and a power button. Moreover, the monitor 209b can advantageously include electronic processing, signal processing, and data storage devices capable of receiving signal data from said sensor 201b, processing the signal data to determine one or more output measurement values indicative of one or more physiological parameters of a monitored patient, and displaying the measurement values, trends of the measurement values, combinations of measurement values, and the like.

**[0098]** The cable 212 connecting the sensor 201b and the monitor 209b can be implemented using one or more wires, optical fiber, flex circuits, or the like. In some embodiments, the cable 212 can employ twisted pairs of conductors in order to minimize or reduce cross-talk of data transmitted from the sensor 201b to the monitor 209b. Various lengths of the cable 212 can be employed to allow for separation between the sensor 201b and the monitor 209b. The cable 212 can be

WO 2010/003134

PCT/US2009/049638

-24-

fitted with a connector (male or female) on either end of the cable 212 so that the sensor 201b and the monitor 209b can be connected and disconnected from each other. Alternatively, the sensor 201b and the monitor 209b can be coupled together via a wireless communication link, such as an infrared link, radio frequency channel, or any other wireless communication protocol and channel.

**[0099]** The monitor 209b can be attached to the patient. For example, the monitor 209b can include a belt clip or straps (see, e.g., FIGURE 2C) that facilitate attachment to a patient's belt, arm, leg, or the like. The monitor 209b can also include a fitting, slot, magnet, LEMO snap-click connector, or other connecting mechanism to allow the cable 212 and sensor 201b to be attached to the monitor 209B.

**[0100]** The monitor 209b can also include other components, such as a speaker, power button, removable storage or memory (e.g., a flash card slot), an AC power port, and one or more network interfaces, such as a universal serial bus interface or an Ethernet port. For example, the monitor 209b can include a display 210b that can indicate a measurement for glucose, for example, in mg/dL. Other analytes and forms of display can also appear on the monitor 209b.

**[0101]** In addition, although a single sensor 201b with a single monitor 209b is shown, different combinations of sensors and device pairings can be implemented. For example, multiple sensors can be provided for a plurality of differing patient types or measurement sites or even patient fingers.

**[0102]** **FIGURE 2C** illustrates yet another example of monitoring device 200C that can house the data collection system 100. Like the monitoring device 200B, the monitoring device 200C includes a finger clip sensor 201c connected to a monitor 209c via a cable 212. The cable 212 can have all of the features described above with respect to FIGURE 2B. The monitor 209c can include all of the features of the monitor 200B described above. For example, the monitor 209c includes buttons 208c and a display 210c. The monitor 209c shown also includes straps 214c that allow the monitor 209c to be attached to a patient's limb or the like.

**[0103]** **FIGURE 2D** illustrates yet another example of monitoring device 200D that can house the data collection system 100. Like the monitoring devices



WO 2010/003134

PCT/US2009/049638

-25-

200B and 200C, the monitoring device 200D includes a finger clip sensor 201d connected to a monitor 209d via a cable 212. The cable 212 can have all of the features described above with respect to FIGURE 2B. In addition to having some or all of the features described above with respect to FIGURES 2B and 2C, the monitoring device 200D includes an optional universal serial bus (USB) port 216 and an Ethernet port 218. The USB port 216 and the Ethernet port 218 can be used, for example, to transfer information between the monitor 209d and a computer (not shown) via a cable. Software stored on the computer can provide functionality for a user to, for example, view physiological data and trends, adjust settings and download firmware updates to the monitor 209b, and perform a variety of other functions. The USB port 216 and the Ethernet port 218 can be included with the other monitoring devices 200A, 200B, and 200C described above.

**[0104] FIGURES 3A through 3C** illustrate more detailed examples of embodiments of a sensor 301a. The sensor 301a shown can include all of the features of the sensors 100 and 200 described above.

**[0105]** Referring to **FIGURE 3A**, the sensor 301a in the depicted embodiment is a clothespin-shaped clip sensor that includes an enclosure 302a for receiving a patient's finger. The enclosure 302a is formed by an upper section or emitter shell 304a, which is pivotably connected with a lower section or detector shell 306a. The emitter shell 304a can be biased with the detector shell 306a to close together around a pivot point 303a and thereby sandwich finger tissue between the emitter and detector shells 304a, 306a.

**[0106]** In an embodiment, the pivot point 303a advantageously includes a pivot capable of adjusting the relationship between the emitter and detector shells 304a, 306a to effectively level the sections when applied to a tissue site. In another embodiment, the sensor 301a includes some or all features of the finger clip described in U.S. Publication No. 2006/0211924, incorporated above, such as a spring that causes finger clip forces to be distributed along the finger. Paragraphs [0096] through [0105], which describe this feature, are hereby specifically incorporated by reference.

WO 2010/003134

PCT/US2009/049638

-26-

**[0107]** The emitter shell 304a can position and house various emitter components of the sensor 301a. It can be constructed of reflective material (e.g., white silicone or plastic) and/or can be metallic or include metalicized plastic (e.g., including carbon and aluminum) to possibly serve as a heat sink. The emitter shell 304a can also include absorbing opaque material, such as, for example, black or grey colored material, at various areas, such as on one or more flaps 307a, to reduce ambient light entering the sensor 301a.

**[0108]** The detector shell 306a can position and house one or more detector portions of the sensor 301a. The detector shell 306a can be constructed of reflective material, such as white silicone or plastic. As noted, such materials can increase the usable signal at a detector by forcing light back into the tissue and measurement site (see FIGURE 1). The detector shell 306a can also include absorbing opaque material at various areas, such as lower area 308a, to reduce ambient light entering the sensor 301a.

**[0109]** Referring to **FIGURES 3B** and **3C**, an example of finger bed 310 is shown in the sensor 301b. The finger bed 310 includes a generally curved surface shaped generally to receive tissue, such as a human digit. The finger bed 310 includes one or more ridges or channels 314. Each of the ridges 314 has a generally convex shape that can facilitate increasing traction or gripping of the patient's finger to the finger bed. Advantageously, the ridges 314 can improve the accuracy of spectroscopic analysis in certain embodiments by reducing noise that can result from a measurement site moving or shaking loose inside of the sensor 301a. The ridges 314 can be made from reflective or opaque materials in some embodiments to further increase SNR. In other implementations, other surface shapes can be used, such as, for example, generally flat, concave, or convex finger beds 310.

**[0110]** Finger bed 310 can also include an embodiment of a tissue thickness adjuster or protrusion 305. The protrusion 305 includes a measurement site contact area 370 (see FIGURE 3C) that can contact body tissue of a measurement site. The protrusion 305 can be removed from or integrated with the finger bed 310. Interchangeable, different shaped protrusions 305 can also be

WO 2010/003134

PCT/US2009/049638

-27-

provided, which can correspond to different finger shapes, characteristics, opacity, sizes, or the like.

**[0111]** Referring specifically to **FIGURE 3C**, the contact area 370 of the protrusion 305 can include openings or windows 320, 321, 322, and 323. When light from a measurement site passes through the windows 320, 321, 322, and 323, the light can reach one or more photodetectors (see FIGURE 3E). In an embodiment, the windows 320, 321, 322, and 323 mirror specific detector placements layouts such that light can impinge through the protrusion 305 onto the photodetectors. Any number of windows 320, 321, 322, and 323 can be employed in the protrusion 305 to allow light to pass from the measurement site to the photodetectors.

**[0112]** The windows 320, 321, 322, and 323 can also include shielding, such as an embedded grid of wiring or a conductive glass coating, to reduce noise from ambient light or other electromagnetic noise. The windows 320, 321, 322, and 323 can be made from materials, such as plastic or glass. In some embodiments, the windows 320, 321, 322, and 323 can be constructed from conductive glass, such as indium tin oxide (ITO) coated glass. Conductive glass can be useful because its shielding is transparent, and thus allows for a larger aperture versus a window with an embedded grid of wiring. In addition, in certain embodiments, the conductive glass does not need openings in its shielding (since it is transparent), which enhances its shielding performance. For example, some embodiments that employ the conductive glass can attain up to an about 40% to about 50% greater signal than non-conductive glass with a shielding grid. In addition, in some embodiments, conductive glass can be useful for shielding noise from a greater variety of directions than non-conductive glass with a shielding grid.

**[0113]** Turning to **FIGURE 3B**, the sensor 301a can also include a shielding 315a, such as a metal cage, box, metal sheet, perforated metal sheet, a metal layer on a non-metal material, or the like. The shielding 315a is provided in the depicted embodiment below or embedded within the protrusion 305 to reduce noise. The shielding 315a can be constructed from a conductive material, such as copper. The shielding 315a can include one or more openings or windows (not

WO 2010/003134

PCT/US2009/049638

-28-

shown). The windows can be made from glass or plastic to thereby allow light that has passed through the windows 320, 321, 322, and 323 on an external surface of the protrusion 305 (see FIGURE 3C) to pass through to one or more photodetectors that can be enclosed or provided below (see FIGURE 3E).

**[0114]** In an embodiment, the photodetectors can be positioned within or directly beneath the protrusion 305 (see FIGURE 3E). In such cases, the mean optical path length from the emitters to the detectors can be reduced and the accuracy of blood analyte measurement can increase. For example, in one embodiment, a convex bump of about 1 mm to about 3 mm in height and about 10 mm<sup>2</sup> to about 60 mm<sup>2</sup> was found to help signal strength by about an order of magnitude versus other shapes. Of course other dimensions and sizes can be employed in other embodiments. Depending on the properties desired, the length, width, and height of the protrusion 305 can be selected. In making such determinations, consideration can be made of protrusion's 305 effect on blood flow at the measurement site and mean path length for optical radiation passing through openings 320, 321, 322, and 323. Patient comfort can also be considered in determining the size and shape of the protrusion.

**[0115]** In an embodiment, the protrusion 305 can include a pliant material, including soft plastic or rubber, which can somewhat conform to the shape of a measurement site. Pliant materials can improve patient comfort and tactility by conforming the measurement site contact area 370 to the measurement site. Additionally, pliant materials can minimize or reduce noise, such as ambient light. Alternatively, the protrusion 305 can be made from a rigid material, such as hard plastic or metal.

**[0116]** Rigid materials can improve measurement accuracy of a blood analyte by conforming the measurement site to the contact area 370. The contact area 370 can be an ideal shape for improving accuracy or reducing noise. Selecting a material for the protrusion 305 can include consideration of materials that do not significantly alter blood flow at the measurement site. The protrusion 305 and the contact area 370 can include a combination of materials with various characteristics.

WO 2010/003134

PCT/US2009/049638

-29-

[0117] The contact area 370 serves as a contact surface for the measurement site. For example, in some embodiments, the contact area 370 can be shaped for contact with a patient's finger. Accordingly, the contact area 370 can be sized and shaped for different sizes of fingers. The contact area 370 can be constructed of different materials for reflective purposes as well as for the comfort of the patient. For example, the contact area 370 can be constructed from materials having various hardness and textures, such as plastic, gel, foam, and the like.

[0118] The formulas and analysis that follow with respect to **FIGURE 5** provide insight into how selecting these variables can alter transmittance and intensity gain of optical radiation that has been applied to the measurement site. These examples do not limit the scope of this disclosure.

[0119] Referring to **FIGURE 5**, a plot 500 is shown that illustrates examples of effects of embodiments of the protrusion 305 on the SNR at various wavelengths of light. As described above, the protrusion 305 can assist in conforming the tissue and effectively reduce its mean path length. In some instances, this effect by the protrusion 305 can have significant impact on increasing the SNR.

[0120] According to the Beer Lambert law, a transmittance of light ( $I$ ) can be expressed as follows:  $I = I_0 * e^{-m*b*c}$ , where  $I_0$  is the initial power of light being transmitted,  $m$  is the path length traveled by the light, and the component " $b*c$ " corresponds to the bulk absorption of the light at a specific wavelength of light. For light at about 1600 nm to about 1700 nm, for example, the bulk absorption component is generally around  $0.7 \text{ mm}^{-1}$ . Assuming a typical finger thickness of about 12 mm and a mean path length of 20 mm due to tissue scattering, then  $I = I_0 * e^{(-20*0.7)}$ .

[0121] In an embodiment where the protrusion 305 is a convex bump, the thickness of the finger can be reduced to 10 mm (from 12 mm) for some fingers and the effective light mean path is reduced to about 16.6 mm from 20 mm (see box 510). This results in a new transmittance,  $I_1 = I_0 * e^{(-16.6*0.7)}$ . A curve for a typical finger (having a mean path length of 20 mm) across various wavelengths is shown in the plot 500 of **FIGURE 5**. The plot 500 illustrates potential effects of the

WO 2010/003134

PCT/US2009/049638

-30-

protrusion 305 on the transmittance. As illustrated, comparing  $I$  and  $I_1$  results in an intensity gain of  $e^{(-16.6 \cdot 0.7)} / e^{(-20 \cdot 0.7)}$ , which is about a 10 times increase for light in the about 1600 nm to about 1700 nm range. Such an increase can affect the SNR at which the sensor can operate. The foregoing gains can be due at least in part to the about 1600 nm to about 1700 nm range having high values in bulk absorptions (water, protein, and the like), e.g., about  $0.7 \text{ mm}^{-1}$ . The plot 500 also shows improvements in the visible/near-infrared range (about 600 nm to about 1300 nm).

**[0122]** The contribution of a the protrusion 305 to increased SNR cannot have been previously recognized by persons having ordinary skill in the art at least in part because currently available devices can have been concerned primarily with conforming to the measurement site for patient comfort. In addition, for light in the visible range and infrared range, or in other words, at the wavelengths of many previous devices, the bulk absorption of light component in the finger is generally much lower at around  $0.1 \text{ mm}^{-1}$ . Therefore, the same change in thickness increases intensity by, for example,  $e^{(-16.6 \cdot 0.1)} / e^{(-20 \cdot 0.1)}$ , which results in about a 1.5 times increase. In currently available devices, such an impact cannot have been significant enough to warrant overriding other considerations, such as patient comfort. It should be noted, however, that the various protrusion 305 designs disclosed herein can increase SNR while also preserving patient comfort.

**[0123]** Turning again to **FIGURES 3A** through **3C**, an example heat sink 350a is also shown. The heat sink 350a can be attached to, or protrude from an outer surface of, the sensor 301a, thereby providing increased ability for various sensor components to dissipate excess heat. By being on the outer surface of the sensor 301a in certain embodiments, the heat sink 350a can be exposed to the air and thereby facilitate more efficient cooling. In an embodiment, one or more of the emitters (see **FIGURE 1**) generate sufficient heat that inclusion of the heat sink 350a can advantageously allows the sensor 301a to remain safely cooled. The heat sink 350a can include one or more materials that help dissipate heat, such as, for example, aluminum, steel, copper, carbon, combinations of the same, or the like. For example, in some embodiments, the emitter shell 304a can include a heat

WO 2010/003134

PCT/US2009/049638

-31-

conducting material that is also readily and relatively inexpensively moldable into desired shapes and forms.

**[0124]** In some embodiments, the heat sink 350a includes metalicized plastic. The metalicized plastic can include aluminum and carbon, for example. The material can allow for improved thermal conductivity and diffusivity, which can increase commercial viability of the heat sink. In some embodiments, the material selected to construct the heat sink 350a can include a thermally conductive liquid crystalline polymer, such as CoolPoly<sup>®</sup> D5506, commercially available from Cool Polymers<sup>®</sup>, Inc. of Warwick, Rhode Island. Such a material can be selected for its electrically non-conductive and dielectric properties so as, for example, to aid in electrical shielding. In an embodiment, the heat sink 350a provides improved heat transfer properties when the sensor 301a is active for short intervals of less than a full day's use. In an embodiment, the heat sink 350a can advantageously provide improved heat transfers in about three (3) to about four (4) minute intervals, for example, although a heat sink 350a can be selected that performs effectively in shorter or longer intervals.

**[0125]** Moreover, the heat sink 350a can have different shapes and configurations for aesthetic as well as for functional purposes. In an embodiment, the heat sink is configured to maximize heat dissipation, for example, by maximizing surface area. In an embodiment, the heat sink 350a is molded into a generally curved surface and includes one or more fins, undulations, grooves, or channels. The example heat sink 350a shown includes fins 351a (see FIGURE 3A).

**[0126]** An alternative shape of a sensor 301b and heat sink 350b is shown in **FIGURE 3D**. The sensor 301b can include some or all of the features of the sensor 301a. For example, the sensor 301b includes an enclosure 302b formed by an emitter shell 304b and a detector shell 306b, pivotably connected about a pivot 303a. The emitter shell 304b can also include absorbing opaque material on one or more flaps 307b, and the detector shell 306a can also include absorbing opaque material at various areas, such as lower area 308b.

**[0127]** However, the shape of the sensor 301b is different in this embodiment. In particular, the heat sink 350b includes comb protrusions 351b. The

WO 2010/003134

PCT/US2009/049638

-32-

comb protrusions 351b are exposed to the air in a similar manner to the fins 351a of the heat sink 350a, thereby facilitating efficient cooling of the sensor 301b.

**[0128] FIGURE 3E** illustrates a more detailed example of a detector shell 306b of the sensor 301b. The features described with respect to the detector shell 306b can also be used with the detector shell 306a of the sensor 301a.

**[0129]** As shown, the detector shell 306b includes detectors 316. The detectors 316 can have a predetermined spacing 340 from each other, or a spatial relationship among one another that results in a spatial configuration. This spatial configuration can purposefully create a variation of path lengths among detectors 316 and the emitter discussed above.

**[0130]** In the depicted embodiment, the detector shell 316 can hold multiple (e.g., two, three, four, etc.) photodiode arrays that are arranged in a two-dimensional grid pattern. Multiple photodiode arrays can also be useful to detect light piping (e.g., light that bypasses measurement site 102). In the detector shell 316, walls can be provided to separate the individual photodiode arrays to prevent or reduce mixing of light signals from distinct quadrants. In addition, the detector shell 316 can be covered by windows of transparent material, such as glass, plastic, or the like, to allow maximum or increased transmission of power light captured. In various embodiments, the transparent materials used can also be partially transparent or translucent or can otherwise pass some or all of the optical radiation passing through them. As noted, this window can include some shielding in the form of an embedded grid of wiring, or a conductive layer or coating.

**[0131]** As further illustrated by **FIGURE 3E**, the detectors 316 can have a spatial configuration of a grid. However, the detectors 316 can be arranged in other configurations that vary the path length. For example, the detectors 316 can be arranged in a linear array, a logarithmic array, a two-dimensional array, or the like. Furthermore, any number of the detectors 316 can be employed in certain embodiments.

**[0132] FIGURE 3F** illustrates another embodiment of a sensor 301f. The sensor 301f can include some or all of the features of the sensor 301a of **FIGURE 3A** described above. For example, the sensor 301f includes an enclosure 302f



WO 2010/003134

PCT/US2009/049638

-33-

formed by an upper section or emitter shell 304f, which is pivotably connected with a lower section or detector shell 306f around a pivot point 303f. The emitter shell 304f can also include absorbing opaque material on various areas, such as on one or more flaps 307f, to reduce ambient light entering the sensor 301f. The detector shell 306f can also include absorbing opaque material at various areas, such as a lower area 308f. The sensor 301f also includes a heat sink 350f, which includes fins 351f.

**[0133]** In addition to these features, the sensor 301f includes a flex circuit cover 360, which can be made of plastic or another suitable material. The flex circuit cover 360 can cover and thereby protect a flex circuit (not shown) that extends from the emitter shell 304f to the detector shell 306f. An example of such a flex circuit is illustrated in U.S. Publication No. 2006/0211924, incorporated above (see FIGURE 46 and associated description, which is hereby specifically incorporated by reference). The flex circuit cover 360 is shown in more detail below in FIGURE 17.

**[0134]** FIGURES 4A through 4C illustrate example arrangements of a protrusion 405, which is an embodiment of the protrusion 305 described above. In an embodiment, the protrusion 405 can include a measurement site contact area 470. The measurement site contact area 470 can include a surface that molds body tissue of a measurement site, such as a finger, into a flat or relatively flat surface.

**[0135]** The protrusion 405 can have dimensions that are suitable for a measurement site such as a patient's finger. As shown, the protrusion 405 can have a length 400, a width 410, and a height 430. The length 400 can be from about 9 to about 11 millimeters, e.g., about 10 millimeters. The width 410 can be from about 7 to about 9 millimeters, e.g., about 8 millimeters. The height 430 can be from about 0.5 millimeters to about 3 millimeters, e.g., about 2 millimeters. In an embodiment, the dimensions 400, 410, and 430 can be selected such that the measurement site contact area 470 includes an area of about 80 square millimeters, although larger and smaller areas can be used for different sized tissue for an adult, an adolescent, or infant, or for other considerations.

WO 2010/003134

PCT/US2009/049638

-34-

[0136] The measurement site contact area 470 can also include differently shaped surfaces that conform the measurement site into different shapes. For example, the measurement site contact area 470 can be generally curved and/or convex with respect to the measurement site. The measurement site contact area 470 can be other shapes that reduce or even minimize air between the protrusion 405 and or the measurement site. Additionally, the surface pattern of the measurement site contact area 470 can vary from smooth to bumpy, e.g., to provide varying levels of grip.

[0137] In **FIGURES 4A** and **4C**, openings or windows 420, 421, 422, and 423 can include a wide variety of shapes and sizes, including for example, generally square, circular, triangular, or combinations thereof. The windows 420, 421, 422, and 423 can be of non-uniform shapes and sizes. As shown, the windows 420, 421, 422, and 423 can be evenly spaced out in a grid like arrangement. Other arrangements or patterns of arranging the windows 420, 421, 422, and 423 are possible. For example, the windows 420, 421, 422, and 423 can be placed in a triangular, circular, or linear arrangement. In some embodiments, the windows 420, 421, 422, and 423 can be placed at different heights with respect to the finger bed 310 of **FIGURE 3**. The windows 420, 421, 422, and 423 can also mimic or approximately mimic a configuration of, or even house, a plurality of detectors.

[0138] **FIGURES 6A** through **6D** illustrate another embodiment of a protrusion 605 that can be used as the tissue shaper 105 described above or in place of the protrusions 305, 405 described above. The depicted protrusion 605 is a partially cylindrical lens having a partial cylinder 608 and an extension 610. The partial cylinder 608 can be a half cylinder in some embodiments; however, a smaller or greater portion than half of a cylinder can be used. Advantageously, in certain embodiments, the partially cylindrical protrusion 605 focuses light onto a smaller area, such that fewer detectors can be used to detect the light attenuated by a measurement site.

[0139] **FIGURE 6A** illustrates a perspective view of the partially cylindrical protrusion 605. **FIGURE 6B** illustrates a front elevation view of the partially cylindrical protrusion 605. **FIGURE 6C** illustrates a side view of the partially

WO 2010/003134

PCT/US2009/049638

-35-

cylindrical protrusion 605. **FIGURE 6D** illustrates a top view of the partially cylindrical protrusion 605.

**[0140]** Advantageously, in certain embodiments, placing the partially cylindrical protrusion 605 over the photodiodes in any of the sensors described above adds multiple benefits to any of the sensors described above. In one embodiment, the partially cylindrical protrusion 605 penetrates into the tissue and reduces the pathlength of the light traveling in the tissue, similar to the protrusions described above.

**[0141]** The partially cylindrical protrusion 605 can also collect light from a large surface and focus down the light to a smaller area. As a result, in certain embodiments, signal strength per area of the photodiode can be increased. The partially cylindrical protrusion 605 can therefore facilitate a lower cost sensor because, in certain embodiments, less photodiode area can be used to obtain the same signal strength. Less photodiode area can be realized by using smaller photodiodes or fewer photodiodes (see, e.g., **FIGURE 14**). If fewer or smaller photodiodes are used, the partially cylindrical protrusion 605 can also facilitate an improved SNR of the sensor because fewer or smaller photodiodes can have less dark current.

**[0142]** The dimensions of the partially cylindrical protrusion 605 can vary based on, for instance, a number of photodiodes used with the sensor. Referring to **FIGURE 6C**, the overall height of the partially cylindrical protrusion 605 (measurement "a") in some implementations is about 1 to about 3 mm. A height in this range can allow the partially cylindrical protrusion 605 to penetrate into the pad of the finger or other tissue and reduce the distance that light travels through the tissue. Other heights, however, of the partially cylindrical protrusion 605 can also accomplish this objective. For example, the chosen height of the partially cylindrical protrusion 605 can be selected based on the size of the measurement site, whether the patient is an adult or child, and so on. In an embodiment, the height of the protrusion 605 is chosen to provide as much tissue thickness reduction as possible while reducing or preventing occlusion of blood vessels in the tissue.

WO 2010/003134

PCT/US2009/049638

-36-

**[0143]** Referring to **FIGURE 6D**, the width of the partially cylindrical protrusion 605 (measurement “b”) can be about 3 to about 5 mm. In one embodiment, the width is about 4 mm. In one embodiment, a width in this range provides good penetration of the partially cylindrical protrusion 605 into the tissue to reduce the pathlength of the light. Other widths, however, of the partially cylindrical protrusion 605 can also accomplish this objective. For example, the width of the partially cylindrical protrusion 605 can vary based on the size of the measurement site, whether the patient is an adult or child, and so on. In addition, the length of the protrusion 605 could be about 10 mm, or about 8 mm to about 12 mm, or smaller than 8 mm or greater than 12 mm.

**[0144]** In certain embodiments, the focal length ( $f$ ) for the partially cylindrical protrusion 605 can be expressed as:  $f = \frac{R}{n-1}$ , where  $R$  is the radius of curvature of the partial cylinder 608 and  $n$  is the index of refraction of the material used. In certain embodiments, the radius of curvature can be between about 1.5 mm and about 2 mm. In another embodiment, the partially cylindrical protrusion 605 can include a material, such as nBK7 glass, with an index of refraction of around 1.5 at 1300 nm, which can provide focal lengths of between about 3 mm and about 4 mm.

**[0145]** A partially cylindrical protrusion 605 having a material with a higher index of refraction such as nSF11 glass (e.g.,  $n=1.75$  at 1300 nm) can provide a shorter focal length and possibly a smaller photodiode chip, but can also cause higher reflections due to the index of refraction mismatch with air. Many types of glass or plastic can be used with index of refraction values ranging from, for example, about 1.4 to about 1.9. The index of refraction of the material of the protrusion 605 can be chosen to improve or optimize the light focusing properties of the protrusion 605. A plastic partially cylindrical protrusion 605 could provide the cheapest option in high volumes but can also have some undesired light absorption peaks at wavelengths higher than 1500 nm. Other focal lengths and materials having different indices of refraction can be used for the partially cylindrical protrusion 605.

WO 2010/003134

PCT/US2009/049638

-37-

**[0146]** Placing a photodiode at a given distance below the partially cylindrical protrusion 605 can facilitate capturing some or all of the light traveling perpendicular to the lens within the active area of the photodiode (see FIGURE 14). Different sizes of the partially cylindrical protrusion 605 can use different sizes of photodiodes. The extension 610 added onto the bottom of the partial cylinder 608 is used in certain embodiments to increase the height of the partially cylindrical protrusion 605. In an embodiment, the added height is such that the photodiodes are at or are approximately at the focal length of the partially cylindrical protrusion 605. In an embodiment, the added height provides for greater thinning of the measurement site. In an embodiment, the added height assists in deflecting light piped through the sensor. This is because light piped around the sensor passes through the side walls of the added height without being directed toward the detectors. The extension 610 can also further facilitate the protrusion 605 increasing or maximizing the amount of light that is provided to the detectors. In some embodiments, the extension 610 can be omitted.

**[0147]** FIGURE 6E illustrates another view of the sensor 301f of FIGURE 3F, which includes an embodiment of a partially cylindrical protrusion 605b. Like the sensor 301A shown in FIGURES 3B and 3C, the sensor 301f includes a finger bed 310f. The finger bed 310f includes a generally curved surface shaped generally to receive tissue, such as a human digit. The finger bed 310f also includes the ridges or channels 314 described above with respect to FIGURES 3B and 3C.

**[0148]** The example of finger bed 310f shown also includes the protrusion 605b, which includes the features of the protrusion 605 described above. In addition, the protrusion 605b also includes chamfered edges 607 on each end to provide a more comfortable surface for a finger to slide across (see also FIGURE 14D). In another embodiment, the protrusion 605b could instead include a single chamfered edge 607 proximal to the ridges 314. In another embodiment, one or both of the chamfered edges 607 could be rounded.

**[0149]** The protrusion 605b also includes a measurement site contact area 670 that can contact body tissue of a measurement site. The protrusion 605b can be removed from or integrated with the finger bed 310f. Interchangeable, differently

WO 2010/003134

PCT/US2009/049638

-38-

shaped protrusions 605b can also be provided, which can correspond to different finger shapes, characteristics, opacity, sizes, or the like.

**[0150]** **FIGURES 7A** and **7B** illustrate block diagrams of sensors 701 that include example arrangements of conductive glass or conductive coated glass for shielding. Advantageously, in certain embodiments, the shielding can provide increased SNR. The features of the sensors 701 can be implemented with any of the sensors 101, 201, 301 described above. Although not shown, the partially cylindrical protrusion 605 of **FIGURE 6** can also be used with the sensors 701 in certain embodiments.

**[0151]** For example, referring specifically to **FIGURE 7A**, the sensor 701a includes an emitter housing 704a and a detector housing 706. The emitter housing 704a includes LEDs 104. The detector housing 706a includes a tissue bed 710a with an opening or window 703a, the conductive glass 730a, and one or more photodiodes for detectors 106 provided on a submount 707a.

**[0152]** During operation, a finger 102 can be placed on the tissue bed 710a and optical radiation can be emitted from the LEDs 104. Light can then be attenuated as it passes through or is reflected from the tissue of the finger 102. The attenuated light can then pass through the opening 703a in the tissue bed 710a. Based on the received light, the detectors 106 can provide a detector signal 107, for example, to the front end interface 108 (see **FIGURE 1**).

**[0153]** In the depicted embodiment, the conductive glass 730 is provided in the opening 703. The conductive glass 730 can thus not only permit light from the finger to pass to the detectors 106, but it can also supplement the shielding of the detectors 106 from noise. The conductive glass 730 can include a stack or set of layers. In **FIGURE 7A**, the conductive glass 730a is shown having a glass layer 731 proximate the finger 102 and a conductive layer 733 electrically coupled to the shielding 790a.

**[0154]** In an embodiment, the conductive glass 730a can be coated with a conductive, transparent or partially transparent material, such as a thin film of indium tin oxide (ITO). To supplement electrical shielding effects of a shielding enclosure 790a, the conductive glass 730a can be electrically coupled to the

WO 2010/003134

PCT/US2009/049638

-39-

shielding enclosure 790a. The conductive glass 730a can be electrically coupled to the shielding 704a based on direct contact or via other connection devices, such as a wire or another component.

**[0155]** The shielding enclosure 790a can be provided to encompass the detectors 106 to reduce or prevent noise. For example, the shielding enclosure 790a can be constructed from a conductive material, such as copper, in the form of a metal cage. The shielding or enclosure a can include an opaque material to not only reduce electrical noise, but also ambient optical noise.

**[0156]** Referring to **FIGURE 7B**, another block diagram of an example sensor 701b is shown. A tissue bed 710b of the sensor 701b includes a protrusion 705b, which is in the form of a convex bump. The protrusion 705b can include all of the features of the protrusions or tissue shaping materials described above. For example, the protrusion 705b includes a contact area 370 that comes in contact with the finger 102 and which can include one or more openings 703b. One or more components of conductive glass 730b can be provided in the openings 703. For example, in an embodiment, each of the openings 703 can include a separate window of the conductive glass 730b. In an embodiment, a single piece of the conductive glass 730b can be used for some or all of the openings 703b. The conductive glass 730b is smaller than the conductive glass 730a in this particular embodiment.

**[0157]** A shielding enclosure 790b is also provided, which can have all the features of the shielding enclosure 790a. The shielding enclosure 790b is smaller than the shielding enclosure 790a; however, a variety of sizes can be selected for the shielding enclosures 790.

**[0158]** **FIGURES 8A** through **8D** illustrate a perspective view, side views, and a bottom elevation view of the conductive glass described above with respect to the sensors 701a, 701b. As shown in the perspective view of **FIGURE 8A** and side view of **FIGURE 8B**, the conductive glass 730 includes the electrically conductive material 733 described above as a coating on the glass layer 731 described above to form a stack. In an embodiment where the electrically conductive material 733 includes indium tin oxide, surface resistivity of the electrically conductive material

WO 2010/003134

PCT/US2009/049638

-40-

733 can range approximately from 30 ohms per square inch to 500 ohms per square inch, or approximately 30, 200, or 500 ohms per square inch. As would be understood by a person of skill in the art from the present disclosure, other resistivities can also be used which are less than 30 ohms or more than 500 ohms. Other transparent, electrically conductive materials can be used as the material 733.

**[0159]** Although the conductive material 733 is shown spread over the surface of the glass layer 731, the conductive material 733 can be patterned or provided on selected portions of the glass layer 731. Furthermore, the conductive material 733 can have uniform or varying thickness depending on a desired transmission of light, a desired shielding effect, and other considerations.

**[0160]** In **FIGURE 8C**, a side view of a conductive glass 830a is shown to illustrate an embodiment where the electrically conductive material 733 is provided as an internal layer between two glass layers 731, 835. Various combinations of integrating electrically conductive material 733 with glass are possible. For example, the electrically conductive material 733 can be a layer within a stack of layers. This stack of layers can include one or more layers of glass 731, 835, as well as one or more layers of conductive material 733. The stack can include other layers of materials to achieve desired characteristics.

**[0161]** In **FIGURE 8D**, a bottom perspective view is shown to illustrate an embodiment where a conductive glass 830b can include conductive material 837 that occupies or covers a portion of a glass layer 839. This embodiment can be useful, for example, to create individual, shielded windows for detectors 106, such as those shown in **FIGURE 3C**. The conductive material 837 can be patterned to include an area 838 to allow light to pass to detectors 106 and one or more strips 841 to couple to the shielding 704 of **FIGURE 7**.

**[0162]** Other configurations and patterns for the conductive material can be used in certain embodiments, such as, for example, a conductive coating lining periphery edges, a conductive coating outlaid in a pattern including a grid or other pattern, a speckled conductive coating, coating outlaid in lines in either direction or diagonally, varied thicknesses from the center out or from the periphery in, or other



WO 2010/003134

PCT/US2009/049638

-41-

suitable patterns or coatings that balance the shielding properties with transparency considerations.

**[0163] FIGURE 9** depicts an example graph 900 that illustrates comparative results obtained by an example sensor having components similar to those disclosed above with respect to FIGURES 7 and 8. The graph 900 depicts the results of the percentage of transmission of varying wavelengths of light for different types of windows used in the sensors described above.

**[0164]** A line 915 on the graph 900 illustrates example light transmission of a window made from plain glass. As shown, the light transmission percentage of varying wavelengths of light is approximately 90% for a window made from plain glass. A line 920 on the graph 900 demonstrates an example light transmission percentage for an embodiment in which a window is made from glass having an ITO coating with a surface resistivity of 500 ohms per square inch. A line 925 on the graph 900 shows an example light transmission for an embodiment in which a window is made from glass that includes a coating of ITO oxide with a surface resistivity of 200 ohms per square inch. A line 930 on the graph 900 shows an example light transmission for an embodiment in which a window is made from glass that includes a coating of ITO oxide with a surface resistivity of 30 ohms per square inch.

**[0165]** The light transmission percentage for a window with currently available embedded wiring can have a light transmission percentage of approximately 70%. This lower percentage of light transmission can be due to the opacity of the wiring employed in a currently available window with wiring. Accordingly, certain embodiments of glass coatings described herein can employ, for example, ITO coatings with different surface resistivity depending on the desired light transmission, wavelengths of light used for measurement, desired shielding effect, and other criteria.

**[0166] FIGURES 10A through 10B** illustrate comparative noise floors of example implementations of the sensors described above. Noise can include optical noise from ambient light and electro-magnetic noise, for example, from surrounding electrical equipment. In **FIGURE 10A**, a graph 1000 depicts possible

WO 2010/003134

PCT/US2009/049638

-42-

noise floors for different frequencies of noise for an embodiment in which one of the sensors described above included separate windows for four (4) detectors 106. One or more of the windows included an embedded grid of wiring as a noise shield. Symbols 1030 - 1033 illustrate the noise floor performance for this embodiment. As can be seen, the noise floor performance can vary for each of the openings and based on the frequency of the noise.

**[0167]** In **FIGURE 10B**, a graph 1050 depicts a noise floor for frequencies of noise 1070 for an embodiment in which the sensor included separate openings for four (4) detectors 106 and one or more windows that include an ITO coating. In this embodiment, a surface resistivity of the ITO used was about 500 ohms per square inch. Symbols 1080 - 1083 illustrate the noise floor performance for this embodiment. As can be seen, the noise floor performance for this embodiment can vary less for each of the openings and provide lower noise floors in comparison to the embodiment of **FIGURE 10A**.

**[0168]** **FIGURE 11** illustrates an example structure for configuring the set of optical sources of the emitters described above. As shown, an emitter 1104 can include a driver 1111, a thermistor 1120, a set of top-emitting LEDs 1102 for emitting red and/or infrared light, a set of side-emitting LEDs 1104 for emitting near infrared light, and a submount 1106.

**[0169]** The thermistor 1120 can be provided to compensate for temperature variations. For example, the thermistor 1120 can be provided to allow for wavelength centroid and power drift of LEDs 1102 and 1104 due to heating. In addition, other thermistors (not shown) can be employed, for example, to measure a temperature of a measurement site. Such a temperature can be helpful in correcting for wavelength drift due to changes in water absorption, which can be temperature dependent, thereby providing more accurate data useful in detecting blood analytes like glucose.

**[0170]** The driver 1105 can provide pulses of current to the emitter 1104. In an embodiment, the driver 1105 drives the emitter 1104 in a progressive fashion, for example, in an alternating manner based on a control signal from, for example, a processor (e.g., the processor 110). For example, the driver 1105 can drive the

WO 2010/003134

PCT/US2009/049638

-43-

emitter 1104 with a series of pulses to about 1 milliwatt (mW) for visible light to light at about 1300 nm and from about 40 mW to about 100 mW for light at about 1600 nm to about 1700 nm. However, a wide number of driving powers and driving methodologies can be used. The driver 1105 can be synchronized with other parts of the sensor and can minimize or reduce any jitter in the timing of pulses of optical radiation emitted from the emitter 1104. In some embodiments, the driver 1105 is capable of driving the emitter 1104 to emit an optical radiation in a pattern that varies by less than about 10 parts-per-million; however other amounts of variation can be used.

**[0171]** The submount 1106 provides a support structure in certain embodiments for aligning the top-emitting LEDs 1102 and the side-emitting LEDs 1104 so that their optical radiation is transmitted generally towards the measurement site. In some embodiments, the submount 1106 is also constructed of aluminum nitride (AlN) or beryllium oxide (BEO) for heat dissipation, although other materials or combinations of materials suitable for the submount 1106 can be used.

**[0172]** **FIGURE 12** illustrates a detector submount 1200 having photodiode detectors that are arranged in a grid pattern on the detector submount 1200 to capture light at different quadrants from a measurement site. One detector submount 1200 can be placed under each window of the sensors described above, or multiple windows can be placed over a single detector submount 1200. The detector submount 1200 can also be used with the partially cylindrical protrusion 605 described above with respect to **FIGURE 6**.

**[0173]** The detectors include photodiode detectors 1-4 that are arranged in a grid pattern on the submount 1200 to capture light at different quadrants from the measurement site. As noted, other patterns of photodiodes, such as a linear row, or logarithmic row, can also be employed in certain embodiments.

**[0174]** **FIGURE 13** illustrates an example multi-stream process 1300. The multi-stream process 1300 can be implemented by the data collection system 100 and/or by any of the sensors described above. As shown, a control signal from a signal processor 1310 controls a driver 1305. In response, an emitter 1304

WO 2010/003134

PCT/US2009/049638

-44-

generates a pulse sequence 1303 from its emitter (e.g., its LEDs) into a measurement site or sites 1302. As described above, in some embodiments, the pulse sequence 1303 is controlled to have a variation of about 10 parts per million or less. Of course, depending on the analyte desired, the tolerated variation in the pulse sequence 1303 can be greater (or smaller).

**[0175]** In response to the pulse sequence 1300, detectors 1 to n (n being an integer) in a detector 1306 capture optical radiation from the measurement site 1302 and provide respective streams of output signals. Each signal from one of detectors 1-n can be considered a stream having respective time slots corresponding to the optical pulses from emitter sets 1-n in the emitter 1304. Although n emitters and n detectors are shown, the number of emitters and detectors need not be the same in certain implementations.

**[0176]** A front end interface 1308 can accept these multiple streams from detectors 1-n and deliver one or more signals or composite signal(s) back to the signal processor 1310. A stream from the detectors 1-n can thus include measured light intensities corresponding to the light pulses emitted from the emitter 1304.

**[0177]** The signal processor 1310 can then perform various calculations to measure the amount of glucose and other analytes based on these multiple streams of signals. In order to help explain how the signal processor 1310 can measure analytes like glucose, a primer on the spectroscopy employed in these embodiments will now be provided.

**[0178]** Spectroscopy is premised upon the Beer-Lambert law. According to this law, the properties of a material, e.g., glucose present in a measurement site, can be deterministically calculated from the absorption of light traveling through the material. Specifically, there is a logarithmic relation between the transmission of light through a material and the concentration of a substance and also between the transmission and the length of the path traveled by the light. As noted, this relation is known as the Beer-Lambert law.

**[0179]** The Beer-Lambert law is usually written as:

**[0180]** Absorbance  $A = m \cdot b \cdot c$ , where:

WO 2010/003134

PCT/US2009/049638

-45-

[0181]  $m$  is the wavelength-dependent molar absorptivity coefficient (usually expressed in units of  $M^{-1} \text{ cm}^{-1}$ );

[0182]  $b$  is the mean path length; and

[0183]  $c$  is the analyte concentration (e.g., the desired parameter).

[0184] In spectroscopy, instruments attempt to obtain the analyte concentration ( $c$ ) by relating absorbance ( $A$ ) to transmittance ( $T$ ). Transmittance is a proportional value defined as:

[0185]  $T = I / I_0$ , where:

[0186]  $I$  is the light intensity measured by the instrument from the measurement site; and

[0187]  $I_0$  is the initial light intensity from the emitter.

[0188] Absorbance ( $A$ ) can be equated to the transmittance ( $T$ ) by the equation:

[0189]  $A = -\log T$

[0190] Therefore, substituting equations from above:

[0191]  $A = -\log (I / I_0)$

[0192] In view of this relationship, spectroscopy thus relies on a proportional-based calculation of  $-\log(I / I_0)$  and solving for analyte concentration ( $c$ ).

[0193] Typically, in order to simplify the calculations, spectroscopy will use detectors that are at the same location in order to keep the path length ( $b$ ) a fixed, known constant. In addition, spectroscopy will employ various mechanisms to definitively know the transmission power ( $I_0$ ), such as a photodiode located at the light source. This architecture can be viewed as a single channel or single stream sensor, because the detectors are at a single location.

[0194] However, this scheme can encounter several difficulties in measuring analytes, such as glucose. This can be due to the high overlap of absorption of light by water at the wavelengths relevant to glucose as well as other factors, such as high self-noise of the components.

[0195] Embodiments of the present disclosure can employ a different approach that in part allows for the measurement of analytes like glucose. Some embodiments can employ a bulk, non-pulsatile measurement in order to confirm or

WO 2010/003134

PCT/US2009/049638

-46-

validate a pulsatile measurement. In addition, both the non-pulsatile and pulsatile measurements can employ, among other things, the multi-stream operation described above in order to attain sufficient SNR. In particular, a single light source having multiple emitters can be used to transmit light to multiple detectors having a spatial configuration.

**[0196]** A single light source having multiple emitters can allow for a range of wavelengths of light to be used. For example, visible, infrared, and near infrared wavelengths can be employed. Varying powers of light intensity for different wavelengths can also be employed.

**[0197]** Secondly, the use of multiple-detectors in a spatial configuration allow for a bulk measurement to confirm or validate that the sensor is positioned correctly. This is because the multiple locations of the spatial configuration can provide, for example, topology information that indicates where the sensor has been positioned. Currently available sensors do not provide such information. For example, if the bulk measurement is within a predetermined range of values, then this can indicate that the sensor is positioned correctly in order to perform pulsatile measurements for analytes like glucose. If the bulk measurement is outside of a certain range or is an unexpected value, then this can indicate that the sensor should be adjusted, or that the pulsatile measurements can be processed differently to compensate, such as using a different calibration curve or adjusting a calibration curve. This feature and others allow the embodiments to achieve noise cancellation and noise reduction, which can be several times greater in magnitude than what is achievable by currently available technology.

**[0198]** In order to help illustrate aspects of the multi-stream measurement approach, the following example derivation is provided. Transmittance (T) can be expressed as:

**[0199]**  $T = e^{-m \cdot b \cdot c}$

**[0200]** In terms of light intensity, this equation can also be rewritten as:

**[0201]**  $I / I_0 = e^{-m \cdot b \cdot c}$

**[0202]** Or, at a detector, the measured light (I) can be expressed as:

**[0203]**  $I = I_0 \cdot e^{-m \cdot b \cdot c}$

WO 2010/003134

PCT/US2009/049638

-47-

**[0204]** As noted, in the present disclosure, multiple detectors (1 to n) can be employed, which results in  $I_1 \dots I_n$  streams of measurements. Assuming each of these detectors have their own path lengths,  $b_1 \dots b_n$ , from the light source, the measured light intensities can be expressed as:

$$\textbf{[0205]} \quad I_n = I_o * e^{-m*b_n*c}$$

**[0206]** The measured light intensities at any two different detectors can be referenced to each other. For example:

$$\textbf{[0207]} \quad I_1/I_n = (I_o * e^{-m*b_1*c}) / (I_o * e^{-m*b_n*c})$$

**[0208]** As can be seen, the terms,  $I_o$ , cancel out and, based on exponent algebra, the equation can be rewritten as:

$$\textbf{[0209]} \quad I_1/I_n = e^{-m(b_1-b_n)*c}$$

**[0210]** From this equation, the analyte concentration (c) can now be derived from bulk signals  $I_1 \dots I_n$  and knowing the respective mean path lengths  $b_1$  and  $b_n$ . This scheme also allows for the cancelling out of  $I_o$ , and thus, noise generated by the emitter 1304 can be cancelled out or reduced. In addition, since the scheme employs a mean path length difference, any changes in mean path length and topological variations from patient to patient are easily accounted. Furthermore, this bulk-measurement scheme can be extended across multiple wavelengths. This flexibility and other features allow embodiments of the present disclosure to measure blood analytes like glucose.

**[0211]** For example, as noted, the non-pulsatile, bulk measurements can be combined with pulsatile measurements to more accurately measure analytes like glucose. In particular, the non-pulsatile, bulk measurement can be used to confirm or validate the amount of glucose, protein, etc. in the pulsatile measurements taken at the tissue at the measurement site(s) 1302. The pulsatile measurements can be used to measure the amount of glucose, hemoglobin, or the like that is present in the blood. Accordingly, these different measurements can be combined to thus determine analytes like blood glucose.

**[0212]** **FIGURE 14A** illustrates an embodiment of a detector submount 1400a positioned beneath the partially cylindrical protrusion 605 of FIGURE 6 (or

WO 2010/003134

PCT/US2009/049638

-48-

alternatively, the protrusion 605b). The detector submount 1400a includes two rows 1408a of detectors 1410a. The partially cylindrical protrusion 605 can facilitate reducing the number and/or size of detectors used in a sensor because the protrusion 605 can act as a lens that focuses light onto a smaller area.

**[0213]** To illustrate, in some sensors that do not include the partially cylindrical protrusion 605, sixteen detectors can be used, including four rows of four detectors each. Multiple rows of detectors can be used to measure certain analytes, such as glucose or total hemoglobin, among others. Multiple rows of detectors can also be used to detect light piping (e.g., light that bypasses the measurement site). However, using more detectors in a sensor can add cost, complexity, and noise to the sensor.

**[0214]** Applying the partially cylindrical protrusion 605 to such a sensor, however, could reduce the number of detectors or rows of detectors used while still receiving the substantially same amount of light, due to the focusing properties of the protrusion 605 (see FIGURE 14B). This is the example situation illustrated in **FIGURE 14**—two rows 1408a of detectors 1410a are used instead of four. Advantageously, in certain embodiments, the resulting sensor can be more cost effective, have less complexity, and have an improved SNR, due to fewer and/or smaller photodiodes.

**[0215]** In other embodiments, using the partially cylindrical protrusion 605 can allow the number of detector rows to be reduced to one or three rows of four detectors. The number of detectors in each row can also be reduced. Alternatively, the number of rows might not be reduced but the size of the detectors can be reduced. Many other configurations of detector rows and sizes can also be provided.

**[0216]** **FIGURE 14B** depicts a front elevation view of the partially cylindrical protrusion 605 (or alternatively, the protrusion 605b) that illustrates how light from emitters (not shown) can be focused by the protrusion 605 onto detectors. The protrusion 605 is placed above a detector submount 1400b having one or more detectors 1410b disposed thereon. The submount 1400b can include any number of rows of detectors 1410, although one row is shown.



WO 2010/003134

PCT/US2009/049638

-49-

**[0217]** Light, represented by rays 1420, is emitted from the emitters onto the protrusion 605. These light rays 1420 can be attenuated by body tissue (not shown). When the light rays 1420 enter the protrusion 605, the protrusion 605 acts as a lens to refract the rays into rays 1422. This refraction is caused in certain embodiments by the partially cylindrical shape of the protrusion 605. The refraction causes the rays 1422 to be focused or substantially focused on the one or more detectors 1410b. Since the light is focused on a smaller area, a sensor including the protrusion 605 can include fewer detectors to capture the same amount of light compared with other sensors.

**[0218] FIGURE 14C** illustrates another embodiment of a detector submount 1400c, which can be disposed under the protrusion 605b (or alternatively, the protrusion 605). The detector submount 1400c includes a single row 1408c of detectors 1410c. The detectors are electrically connected to conductors 1412c, which can be gold, silver, copper, or any other suitable conductive material.

**[0219]** The detector submount 1400c is shown positioned under the protrusion 605b in a detector subassembly 1450 illustrated in **FIGURE 14D**. A top-down view of the detector subassembly 1450 is also shown in **FIGURE 14E**. In the detector subassembly 1450, a cylindrical housing 1430 is disposed on the submount 1400c. The cylindrical housing 1430 includes a transparent cover 1432, upon which the protrusion 605b is disposed. Thus, as shown in **FIGURE 14D**, a gap 1434 exists between the detectors 1410c and the protrusion 605b. The height of this gap 1434 can be chosen to increase or maximize the amount of light that impinges on the detectors 1410c.

**[0220]** The cylindrical housing 1430 can be made of metal, plastic, or another suitable material. The transparent cover 1432 can be fabricated from glass or plastic, among other materials. The cylindrical housing 1430 can be attached to the submount 1400c at the same time or substantially the same time as the detectors 1410c to reduce manufacturing costs. A shape other than a cylinder can be selected for the housing 1430 in various embodiments.

**[0221]** In certain embodiments, the cylindrical housing 1430 (and transparent cover 1432) forms an airtight or substantially airtight or hermetic seal

WO 2010/003134

PCT/US2009/049638

-50-

with the submount 1400c. As a result, the cylindrical housing 1430 can protect the detectors 1410c and conductors 1412c from fluids and vapors that can cause corrosion. Advantageously, in certain embodiments, the cylindrical housing 1430 can protect the detectors 1410c and conductors 1412c more effectively than currently-available resin epoxies, which are sometimes applied to solder joints between conductors and detectors.

**[0222]** In embodiments where the cylindrical housing 1430 is at least partially made of metal, the cylindrical housing 1430 can provide noise shielding for the detectors 1410c. For example, the cylindrical housing 1430 can be soldered to a ground connection or ground plane on the submount 1400c, which allows the cylindrical housing 1430 to reduce noise. In another embodiment, the transparent cover 1432 can include a conductive material or conductive layer, such as conductive glass or plastic. The transparent cover 1432 can include any of the features of the noise shields 790 described above.

**[0223]** The protrusion 605b includes the chamfered edges 607 described above with respect to FIGURE 6E. These chamfered edges 607 can allow a patient to more comfortably slide a finger over the protrusion 605b when inserting the finger into the sensor 301f.

**[0224]** **FIGURE 14F** illustrates a portion of the detector shell 306f, which includes the detectors 1410c on the substrate 1400c. The substrate 1400c is enclosed by a shielding enclosure 1490, which can include the features of the shielding enclosures 790a, 790b described above (see also FIGURE 17). The shielding enclosure 1490 can be made of metal. The shielding enclosure 1490 includes a window 1492a above the detectors 1410c, which allows light to be transmitted onto the detectors 1410c.

**[0225]** A noise shield 1403 is disposed above the shielding enclosure 1490. The noise shield 1403, in the depicted embodiment, includes a window 1492a corresponding to the window 1492a. Each of the windows 1492a, 1492b can include glass, plastic, or can be an opening without glass or plastic. In some embodiments, the windows 1492a, 1492b may be selected to have different sizes or shapes from each other.

WO 2010/003134

PCT/US2009/049638

-51-

**[0226]** The noise shield 1403 can include any of the features of the conductive glass described above. In the depicted embodiment, the noise shield 1403 extends about three-quarters of the length of the detector shell 306f. In other embodiments, the noise shield 1403 could be smaller or larger. The noise shield 1403 could, for instance, merely cover the detectors 1410c, the submount 1400c, or a portion thereof. The noise shield 1403 also includes a stop 1413 for positioning a measurement site within the sensor 301f. Advantageously, in certain embodiments, the noise shield 1403 can reduce noise caused by light piping.

**[0227]** A thermistor 1470 is also shown. The thermistor 1470 is attached to the submount 1400c and protrudes above the noise shield 1403. As described above, the thermistor 1470 can be employed to measure a temperature of a measurement site. Such a temperature can be helpful in correcting for wavelength drift due to changes in water absorption, which can be temperature dependent, thereby providing more accurate data useful in detecting blood analytes like glucose.

**[0228]** In the depicted embodiment, the detectors 1410c are not enclosed in the cylindrical housing 1430. In an alternative embodiment, the cylindrical housing 1430 encloses the detectors 1410c and is disposed under the noise shield 1403. In another embodiment, the cylindrical housing 1430 encloses the detectors 1410c and the noise shield 1403 is not used. If both the cylindrical housing 1403 and the noise shield 1403 are used, either or both can have noise shielding features.

**[0229]** **FIGURE 14G** illustrates the detector shell 306f of **FIGURE 14F**, with the finger bed 310f disposed thereon. **FIGURE 14H** illustrates the detector shell 306f of **FIGURE 14G**, with the protrusion 605b disposed in the finger bed 310f.

**[0230]** **FIGURE 14I** illustrates a cutaway view of the sensor 301f. Not all features of the sensor 301f are shown, such as the protrusion 605b. Features shown include the emitter and detector shells 304f, 306f, the flaps 307f, the heat sink 350f and fins 351f, the finger bed 310f, and the noise shield 1403.

**[0231]** In addition to these features, emitters 1404 are depicted in the emitter shell 304f. The emitters 1404 are disposed on a submount 1401, which is

WO 2010/003134

PCT/US2009/049638

-52-

connected to a circuit board 1419. The emitters 1404 are also enclosed within a cylindrical housing 1480. The cylindrical housing 1480 can include all of the features of the cylindrical housing 1430 described above. For example, the cylindrical housing 1480 can be made of metal, can be connected to a ground plane of the submount 1401 to provide noise shielding, and can include a transparent cover 1482.

**[0232]** The cylindrical housing 1480 can also protect the emitters 1404 from fluids and vapors that can cause corrosion. Moreover, the cylindrical housing 1480 can provide a gap between the emitters 1404 and the measurement site (not shown), which can allow light from the emitters 1404 to even out or average out before reaching the measurement site.

**[0233]** The heat sink 350f, in addition to including the fins 351f, includes a protuberance 352f that extends down from the fins 351f and contacts the submount 1401. The protuberance 352f can be connected to the submount 1401, for example, with thermal paste or the like. The protuberance 352f can sink heat from the emitters 1404 and dissipate the heat via the fins 351f.

**[0234]** **FIGURES 15A and 15B** illustrate embodiments of sensor portions 1500A, 1500B that include alternative heat sink features to those described above. These features can be incorporated into any of the sensors described above. For example, any of the sensors above can be modified to use the heat sink features described below instead of or in addition to the heat sink features of the sensors described above.

**[0235]** The sensor portions 1500A, 1500B shown include LED emitters 1504; however, for ease of illustration, the detectors have been omitted. The sensor portions 1500A, 1500B shown can be included, for example, in any of the emitter shells described above.

**[0236]** The LEDs 1504 of the sensor portions 1500A, 1500B are connected to a substrate or submount 1502. The submount 1502 can be used in place of any of the submounts described above. The submount 1502 can be a non-electrically conducting material made of any of a variety of materials, such as ceramic, glass, or the like. A cable 1512 is attached to the submount 1502 and

WO 2010/003134

PCT/US2009/049638

-53-

includes electrical wiring 1514, such as twisted wires and the like, for communicating with the LEDs 1504. The cable 1512 can correspond to the cables 212 described above.

**[0237]** Although not shown, the cable 1512 can also include electrical connections to a detector. Only a portion of the cable 1512 is shown for clarity. The depicted embodiment of the cable 1512 includes an outer jacket 1510 and a conductive shield 1506 disposed within the outer jacket 1510. The conductive shield 1506 can be a ground shield or the like that is made of a metal such as braided copper or aluminum. The conductive shield 1506 or a portion of the conductive shield 1506 can be electrically connected to the submount 1502 and can reduce noise in the signal generated by the sensor 1500A, 1500B by reducing RF coupling with the wires 1514. In alternative embodiments, the cable 1512 does not have a conductive shield. For example, the cable 1512 could be a twisted pair cable or the like, with one wire of the twisted pair used as a heat sink.

**[0238]** Referring specifically to **FIGURE 15A**, in certain embodiments, the conductive shield 1506 can act as a heat sink for the LEDs 1504 by absorbing thermal energy from the LEDs 1504 and/or the submount 1502. An optional heat insulator 1520 in communication with the submount 1502 can also assist with directing heat toward the conductive shield 1506. The heat insulator 1520 can be made of plastic or another suitable material. Advantageously, using the conductive shield 1506 in the cable 1512 as a heat sink can, in certain embodiments, reduce cost for the sensor.

**[0239]** Referring to **FIGURE 15B**, the conductive shield 1506 can be attached to both the submount 1502 and to a heat sink layer 1530 sandwiched between the submount 1502 and the optional insulator 1520. Together, the heat sink layer 1530 and the conductive shield 1506 in the cable 1512 can absorb at least part of the thermal energy from the LEDs and/or the submount 1502.

**[0240]** **FIGURES 15C** and **15D** illustrate implementations of a sensor portion 1500C that includes the heat sink features of the sensor portion 1500A described above with respect to **FIGURE 15A**. The sensor portion 1500C includes the features of the sensor portion 1500A, except that the optional insulator 1520 is

WO 2010/003134

PCT/US2009/049638

-54-

not shown. **FIGURE 15D** is a side cutaway view of the sensor portion 1500C that shows the emitters 1504.

**[0241]** The cable 1512 includes the outer jacket 1510 and the conductive shield 1506. The conductive shield 1506 is soldered to the submount 1502, and the solder joint 1561 is shown. In some embodiments, a larger solder joint 1561 can assist with removing heat more rapidly from the emitters 1504. Various connections 1563 between the submount 1502 and a circuit board 1519 are shown. In addition, a cylindrical housing 1580, corresponding to the cylindrical housing 1480 of **FIGURE 14I**, is shown protruding through the circuit board 1519. The emitters 1504 are enclosed in the cylindrical housing 1580.

**[0242]** **FIGURES 15E** and **15F** illustrate implementations of a sensor portion 1500E that includes the heat sink features of the sensor portion 1500B described above with respect to **FIGURE 15B**. The sensor portion 1500E includes the heat sink layer 1530. The heat sink layer 1530 can be a metal plate, such as a copper plate or the like. The optional insulator 1520 is not shown. **FIGURE 15F** is a side cutaway view of the sensor portion 1500E that shows the emitters 1504.

**[0243]** In the depicted embodiment, the conductive shield 1506 of the cable 1512 is soldered to the heat sink layer 1530 instead of the submount 1502. The solder joint 1565 is shown. In some embodiments, a larger solder joint 1565 can assist with removing heat more rapidly from the emitters 1504. Various connections 1563 between the submount 1502 and a circuit board 1519 are shown. In addition, the cylindrical housing 1580 is shown protruding through the circuit board 1519. The emitters 1504 are enclosed in the cylindrical housing 1580.

**[0244]** **FIGURES 15G** and **15H** illustrate embodiments of connector features that can be used with any of the sensors described above with respect to **FIGURES 1** through **15F**. Referring to **FIGURE 15G**, the circuit board 1519 includes a female connector 1575 that mates with a male connector 1577 connected to a daughter board 1587. The daughter board 1587 includes connections to the electrical wiring 1514 of the cable 1512. The connected boards 1519, 1587 are shown in **FIGURE 15H**. Also shown is a hole 1573 that can receive the cylindrical housing 1580 described above.

WO 2010/003134

PCT/US2009/049638

-55-

**[0245]** Advantageously, in certain embodiments, using a daughter board 1587 to connect to the circuit board 1519 can enable connections to be made more easily to the circuit board 1519. In addition, using separate boards can be easier to manufacture than a single circuit board 1519 with all connections soldered to the circuit board 1519.

**[0246] FIGURES 16A and 16B** illustrate embodiments of disposable optical sensors 1600. In an embodiment, any of the features described above, such as protrusion, shielding, and/or heat sink features, can be incorporated into the disposable sensors 1600 shown. For instance, the sensors 1600 can be used as the sensors 101 in the system 100 described above with respect to FIGURE 1. Moreover, any of the features described above, such as protrusion, shielding, and/or heat sink features, can be implemented in other disposable sensor designs that are not depicted herein.

**[0247]** The sensors 1600 include an adult/pediatric sensor 1610 for finger placement and a disposable infant/neonate sensor 1602 configured for toe, foot or hand placement. Each sensor 1600 has a tape end 1610 and an opposite connector end 1620 electrically and mechanically interconnected via a flexible coupling 1630. The tape end 1610 attaches an emitter and detector to a tissue site. Although not shown, the tape end 1610 can also include any of the protrusion, shielding, and/or heat sink features described above. The emitter illuminates the tissue site and the detector generates a sensor signal responsive to the light after tissue absorption, such as absorption by pulsatile arterial blood flow within the tissue site.

**[0248]** The sensor signal is communicated via the flexible coupling 1630 to the connector end 1620. The connector end 1620 can mate with a cable (not shown) that communicates the sensor signal to a monitor (not shown), such as any of the cables or monitors shown above with respect to FIGURES 2A through 2D. Alternatively, the connector end 1620 can mate directly with the monitor.

**[0249] FIGURE 17** illustrates an exploded view of certain of the components of the sensor 301f described above. A heat sink 1751 and a cable 1781 attach to an emitter shell 1704. The emitter shell attaches to a flap housing

WO 2010/003134

PCT/US2009/049638

-56-

1707. The flap housing 1707 includes a receptacle 1709 to receive a cylindrical housing 1480/1580 (not shown) attached to an emitter submount 1702, which is attached to a circuit board 1719.

**[0250]** A spring 1787 attaches to a detector shell 1706 via pins 1783, 1785, which hold the emitter and detector shells 1704, 1706 together. A support structure 1791 attaches to the detector shell 1706, which provides support for a shielding enclosure 1790. A noise shield 1713 attaches to the shielding enclosure 1790. A detector submount 1700 is disposed inside the shielding enclosure 1790. A finger bed 1710 attaches to the noise shield 1703. A partially cylindrical protrusion 1705 is disposed in the finger bed 1710. Moreover, a flex circuit cover 1706 attaches to the pins 1783, 1785. Although not shown, a flex circuit can also be provided that connects the circuit board 1719 with the submount 1700 (or a circuit board to which the submount 1700 is connected).

**[0251]** Conditional language used herein, such as, among others, "can," "could," "might," "may," "e.g.," and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or states. Thus, such conditional language is not generally intended to imply that features, elements and/or states are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or states are included or are to be performed in any particular embodiment.

**[0252]** While certain embodiments of the inventions disclosed herein have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions disclosed herein. Indeed, the novel methods and systems described herein can be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein can be made without departing from the spirit of the inventions disclosed herein. The claims and their equivalents are



**WO 2010/003134**

**PCT/US2009/049638**

-57-

intended to cover such forms or modifications as would fall within the scope and spirit of certain of the inventions disclosed herein.

WO 2010/003134

PCT/US2009/049638

-58-

WHAT IS CLAIMED IS:

1. A noninvasive physiological sensor for measuring one or more physiological parameters of a medical patient, the sensor comprising:

a light source;

a photodetector operative to detect light from said light source after attenuation by body tissue of a medical patient and to generate a physiological signal responsive to the detected light, the physiological signal reflecting one or more physiological parameters of the medical patient; and

a bump interposed between the light source and the photodetector, the bump protruding from a tissue contacting surface, the bump configured to reduce a thickness of the body tissue between the light source and the photodetector such that an optical pathlength between the light source and the photodetector is reduced.

2. The sensor of Claim 1, wherein the bump comprises a partially cylindrical lens.

3. The sensor of Claim 2, wherein the partially cylindrical lens comprises a height of about 1 mm to 3 mm.

4. The sensor of Claim 2, wherein the partially cylindrical lens comprises a width of about 3 mm to 5 mm.

5. The sensor of Claim 2, wherein the partially cylindrical lens comprises a radius of curvature of about 1.5 mm to 2 mm.

6. The sensor of Claim 2, wherein the partially cylindrical lens comprises an index of refraction of about 1.4 to 1.9.

7. The sensor of Claim 6, wherein a value of the index of refraction facilitates optimizing the light focusing properties of the partially cylindrical lens.

8. The sensor of Claim 2, wherein the partially cylindrical lens comprises a focal length of about 3 mm to 4 mm.

9. The sensor of Claim 2, wherein the partially cylindrical lens is configured to avoid substantially occluding blood vessels in the body tissue.

10. The sensor of Claim 1, wherein the bump comprises an opaque material.

WO 2010/003134

PCT/US2009/049638

-59-

11. The sensor of Claim 1, further comprising shielding housed beneath the bump.
12. The sensor of Claim 1, wherein the shielding comprises a metal material.
13. The sensor of Claim 1, further comprising one or more ridges rising from said tissue contacting surface, the one or more ridges configured to reduce slippage of the measurement site.
14. The sensor of Claim 1, wherein the one or more ridges comprises a silicone material.
15. A noninvasive physiological sensor for measuring one or more physiological parameters of a medical patient, the sensor comprising:
  - a light source;
  - one or more photodetectors operative to detect light from said light source after attenuation by body tissue of a medical patient and to generate a physiological signal responsive to the detected light; and
  - a partially cylindrical lens interposed between the light source and the photodetector.
16. The sensor of Claim 15, wherein the partially cylindrical lens protrudes from a tissue contacting surface.
17. The sensor of Claim 15, wherein the partially cylindrical lens reduces a thickness of the body tissue of the medical patient.
18. The sensor of Claim 15, wherein the partially cylindrical lens reduces a thickness of the body tissue of the medical patient without substantially occluding blood vessels of the medical patient.
19. The sensor of Claim 15, wherein the partially cylindrical lens reduces an optical pathlength between the light source and the one or more photodetectors.
20. The sensor of Claim 15, wherein the partially cylindrical lens facilitates using fewer rows of the one or more photodetectors than are used in a sensor without the partially cylindrical lens, while still receiving the substantially same amount of light.

WO 2010/003134

PCT/US2009/049638

-60-

21. The sensor of Claim 15, wherein the partially cylindrical lens facilitates using smaller photodetectors than are used in a sensor without the partially cylindrical lens, while still receiving the substantially same amount of light.

22. A physiological sensor capable of outputting a signal responsive to a blood analyte present in a monitored patient, the sensor comprising:

a sensor housing comprising an optical source configured to emit optical radiation on a body tissue of a medical patient;

a heat sink associated with the sensor, the heat sink operative to receive thermal energy from the optical source and release thermal energy outside of the sensor housing; and

a plurality of photodetectors each configured to detect the optical radiation from the optical source after attenuation by the body tissue of the medical patient and to output a signal responsive to the detected optical radiation, the signal reflecting one or more physiological parameters of the medical patient.

23. The sensor of Claim 22, wherein the heat sink is at least partially exposed to air when the sensor is applied to the patient.

24. The sensor of Claim 22, wherein the heat sink comprises a conductive shield of a medical cable, the conductive shield being in electrical communication with a substrate, the substrate being in electrical communication with the optical source.

25. The sensor of Claim 24, further comprising an insulator connected to the substrate.

26. The sensor of Claim 22, further comprising a heat sink layer in electrical communication with the substrate and the conductive shielding.

27. The sensor of Claim 26, further comprising an insulator connected to the substrate and to the heat sink layer.

28. The sensor of Claim 22, wherein the heat sink comprises one or more fins.

29. The sensor of Claim 22, wherein the heat sink comprises a comb.

WO 2010/003134

PCT/US2009/049638

-61-

30. The sensor of Claim 22, wherein the heat sink comprises a metalized plastic.

31. The sensor of Claim 22, wherein the heat sink comprises carbon and aluminum material.

32. A heat sink of a noninvasive optical medical sensor capable of detecting light attenuated by body tissue, the heat sink comprising:

a heat producing part of an electronic device; and

a cable in thermal communication with the heat producing part, the cable comprising a conductor configured to draw heat from the heat producing part.

33. The heat sink of Claim 32, wherein the conductor comprises shielding.

34. The heat sink of Claim 32, wherein a portion of the shielding is thermally coupled with the heat producing part.

35. The heat sink of Claim 32, wherein the conductor comprises a wire of a twisted pair of wires.

36. The heat sink of Claim 32, further comprising a heat sink layer in thermal communication with the heat producing part and with the conductor.

37. The heat sink of Claim 32, wherein the heat producing part comprises an emitter of an optical sensor.

38. The heat sink of Claim 37, wherein the conductor is soldered to a submount of the emitter.

39. A conductive shield configured to shield noise interference from a light sensitive detector, the shield comprising:

a substantially transparent material; and

a conductive material disposed on at least a portion of the substantially transparent material;

wherein the conductive shield is configured to be positioned between a light source and a light detector such that at least some light from said light source passes through said conductive shield and impinges on said light detector.

WO 2010/003134

PCT/US2009/049638

-62-

40. The conductive shield of claim 39, wherein the conductive material is configured to be in electrical communication with a ground conductor.

41. The conductive shield of claim 40, wherein the conductive material conducts noise away from said detector toward the ground conductor.

42. The conductive detector shield of claim 39, wherein the substantially transparent material comprises plastic.

43. The conductive detector shield of claim 39, wherein the substantially transparent material comprises glass.

44. The conductive detector shield of claim 39, wherein a surface resistivity of the conductive material ranges from about 30 ohms per square inch to about 500 ohms per square inch.

45. The conductive detector shield of claim 39, wherein the conductive material comprises indium tin oxide.

46. The conductive detector shield of claim 39, wherein the conductive material is a coating on the substantially transparent material, said coating being distributed over the substantially transparent material in a manner selected from the group consisting of: distributed with an even thickness, distributed in varying thicknesses, distributed over the periphery edges of the transparent portion, distributed in a speckled pattern, distributed in a grid, and distributed in lines.

47. An optical medical sensor configured to detect light attenuated by body tissue of a patient, the sensor comprising:

an emitter configured to emit optical radiation;

a detector; and

a noise shield comprising:

a substantially-transparent, electrically-conductive material configured to reduce noise received by the detector, and

a window in the substantially-transparent, electrically-conductive material, the window configured to pass at least a portion of the optical radiation to the detector.

48. The sensor of Claim 47, wherein the window comprises glass.

49. The sensor of Claim 47, wherein the window comprises an opening.

WO 2010/003134

PCT/US2009/049638

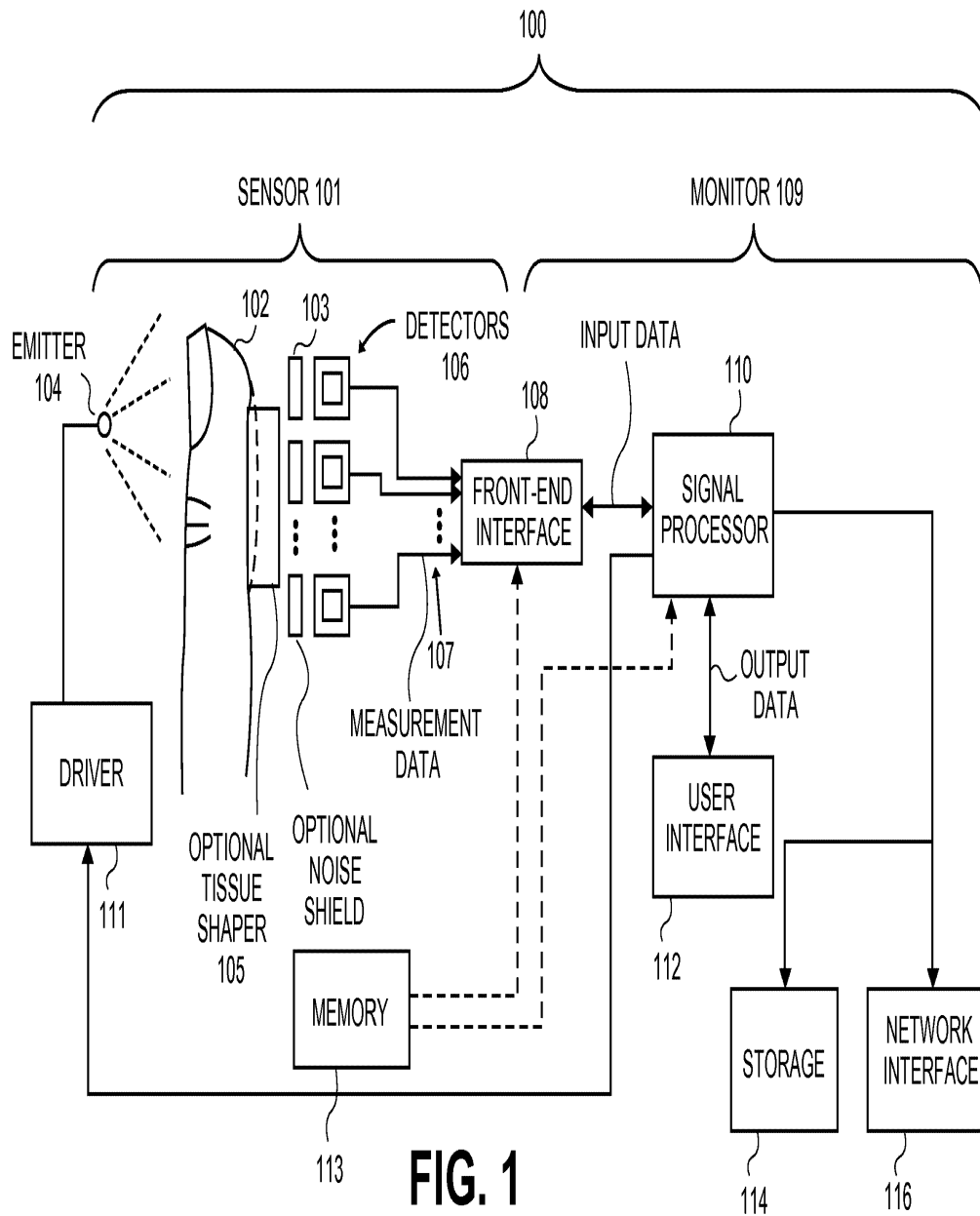
-63-

50. The sensor of claim 47, further comprising a shielding enclosure, the shielding enclosure configured to at least partially encompass the detector.

51. The sensor of claim 50, wherein the shielding enclosure comprises a second window positioned above the detector.

52. The sensor of claim 50, wherein the shielding enclosure comprises metal.

53. The sensor of claim 50, wherein the noise shielding is supported by the shielding enclosure.



1 / 43

WO 2010/003134

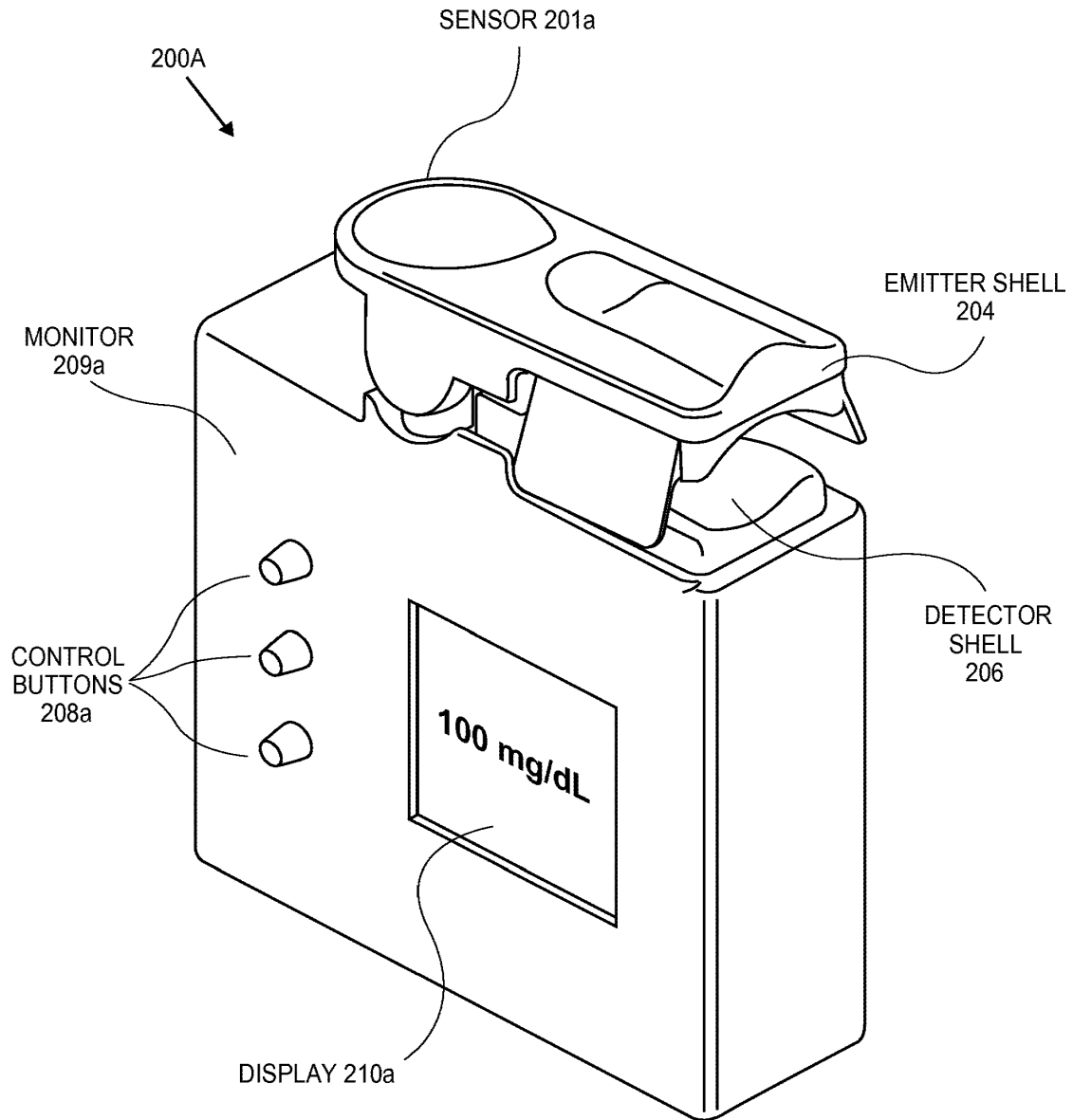
PCT/US2009/049638



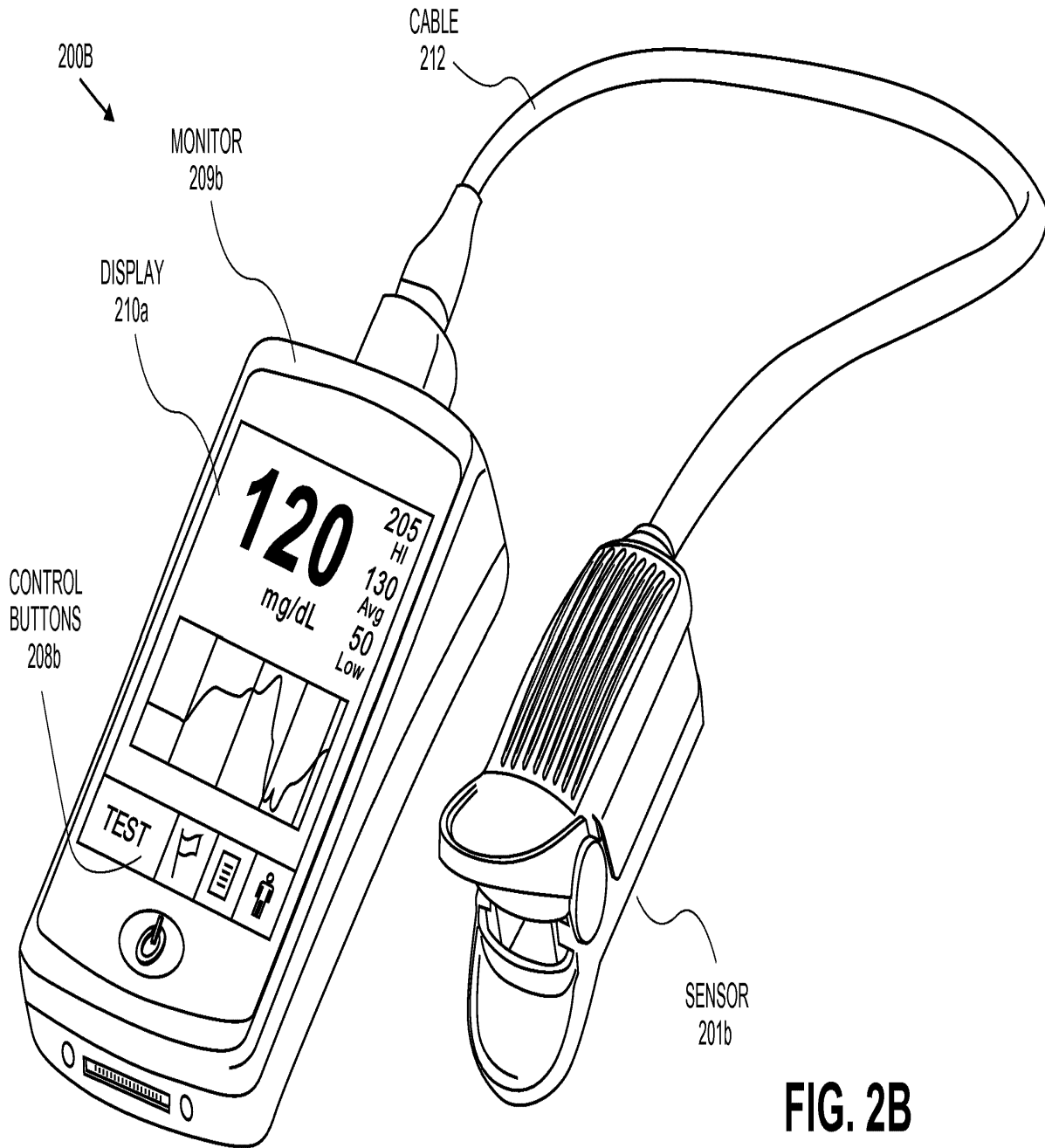
WO 2010/003134

PCT/US2009/049638

2 / 43



**FIG. 2A**



WO 2010/003134

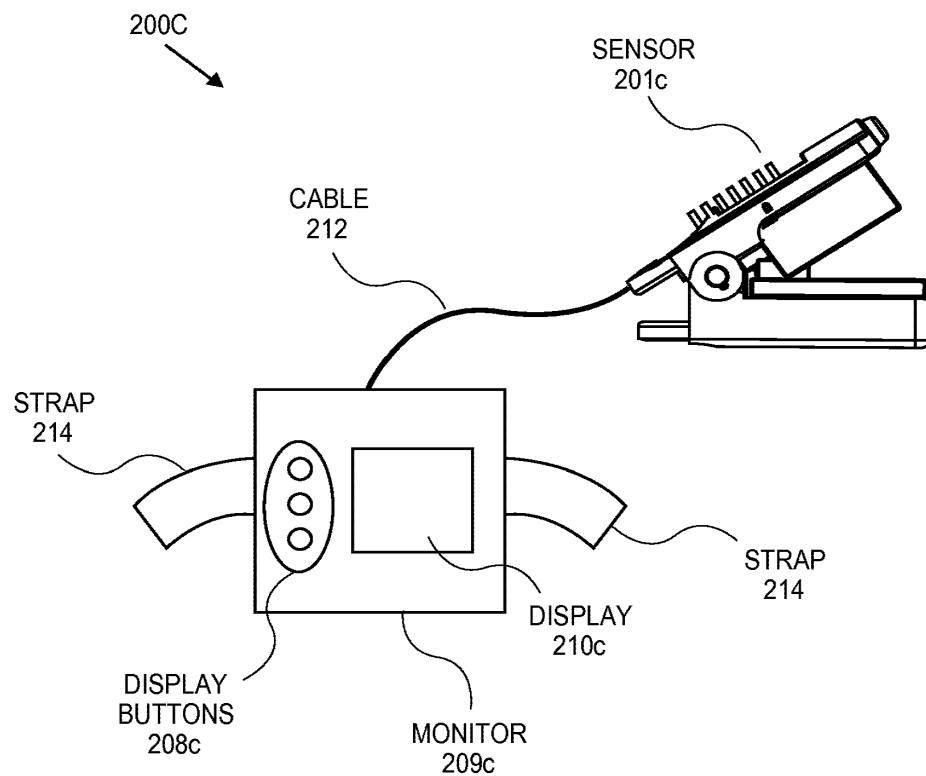
3 / 43

PCT/US2009/049638

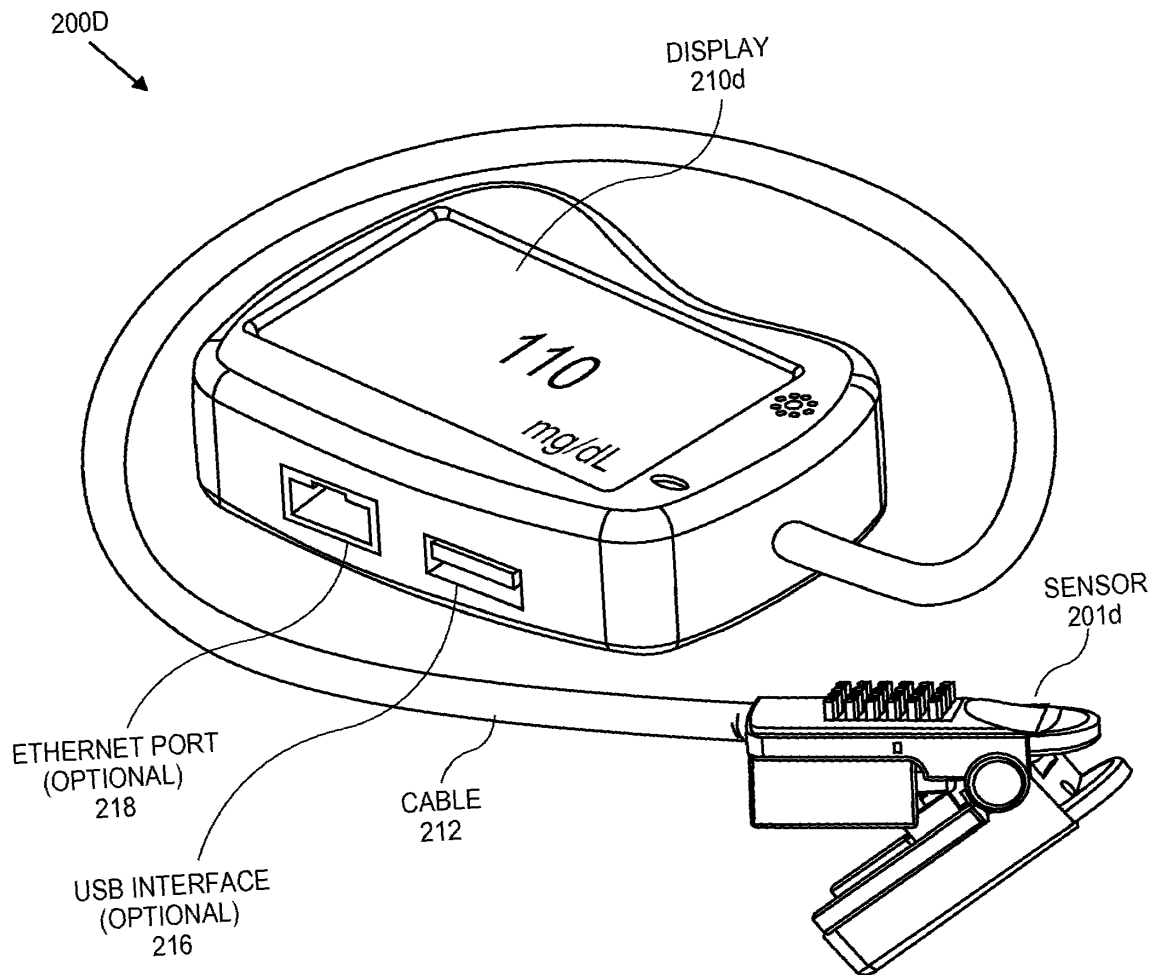
WO 2010/003134

PCT/US2009/049638

4 / 43



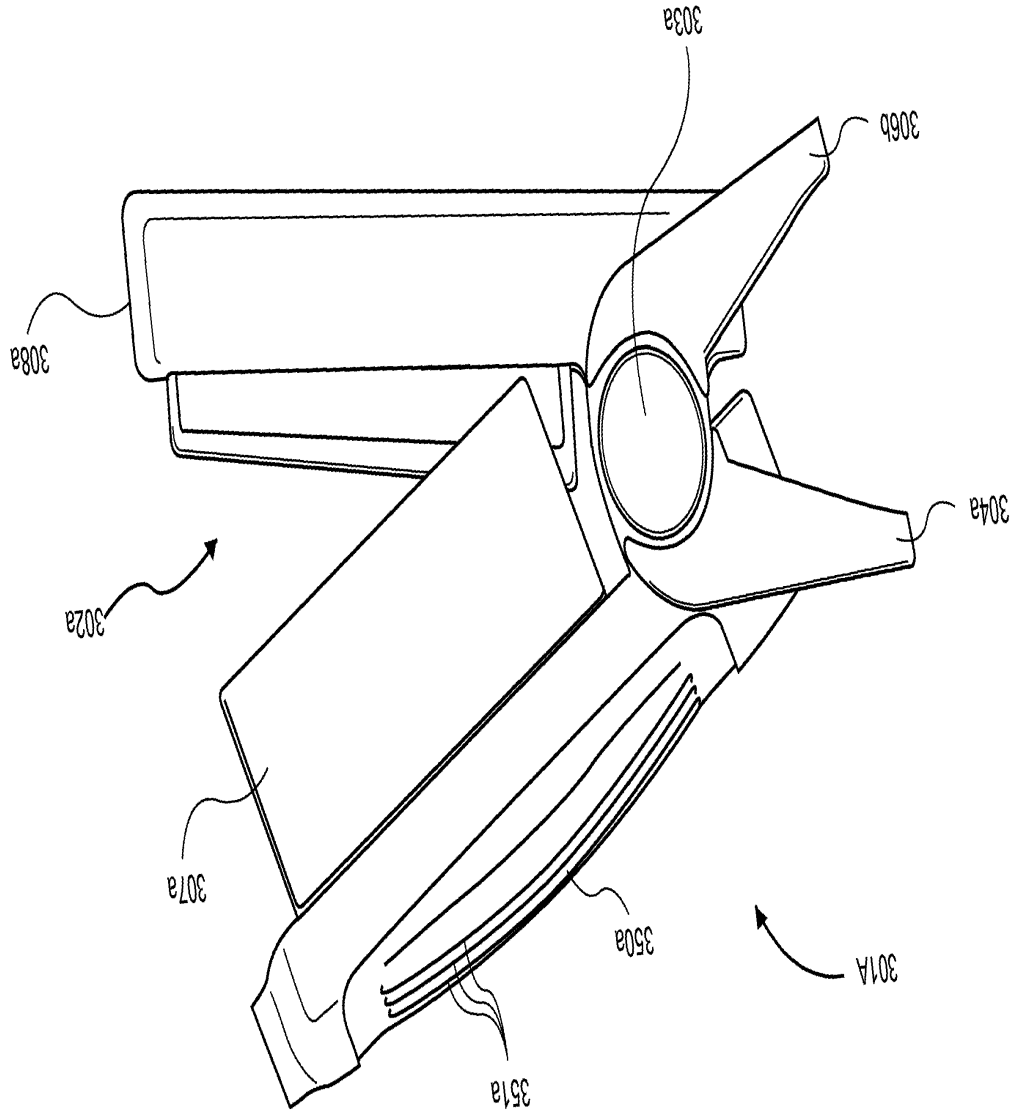
**FIG. 2C**



**FIG. 2D**

WO 2010/003134

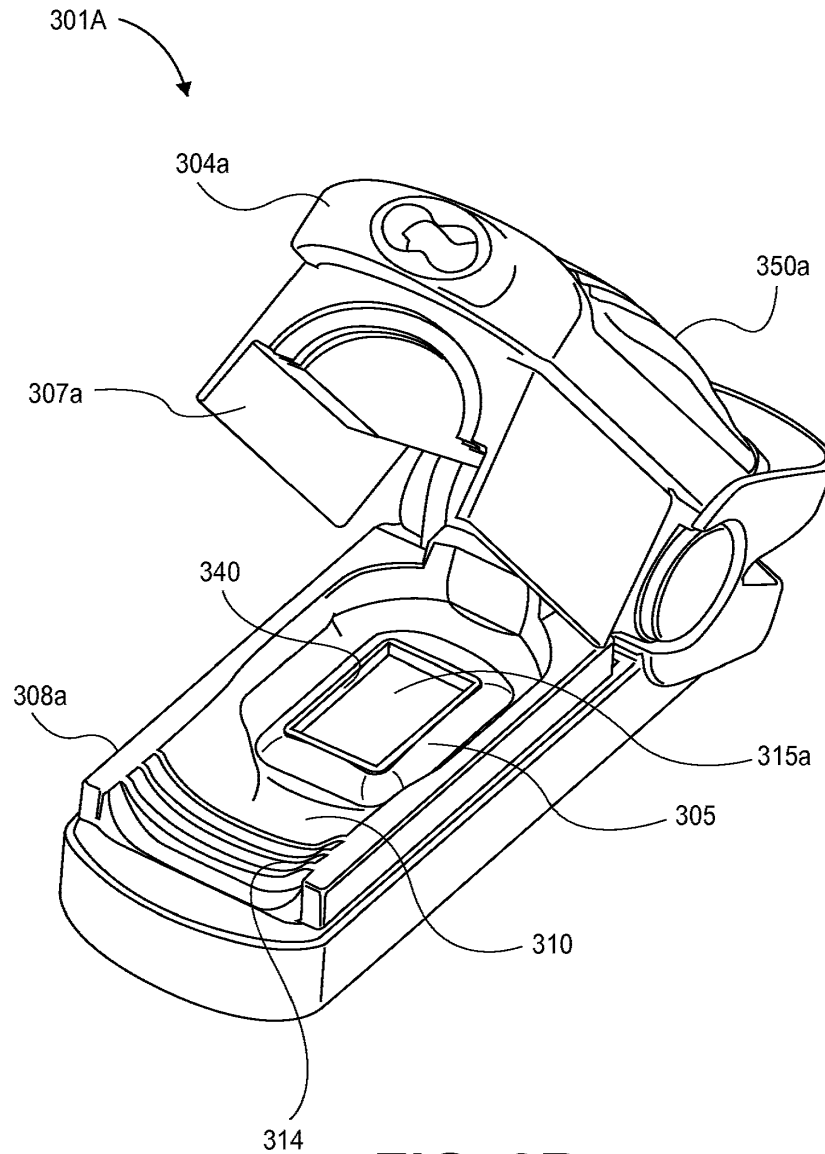
6 / 43



WO 2010/003134

PCT/US2009/049638

7 / 43

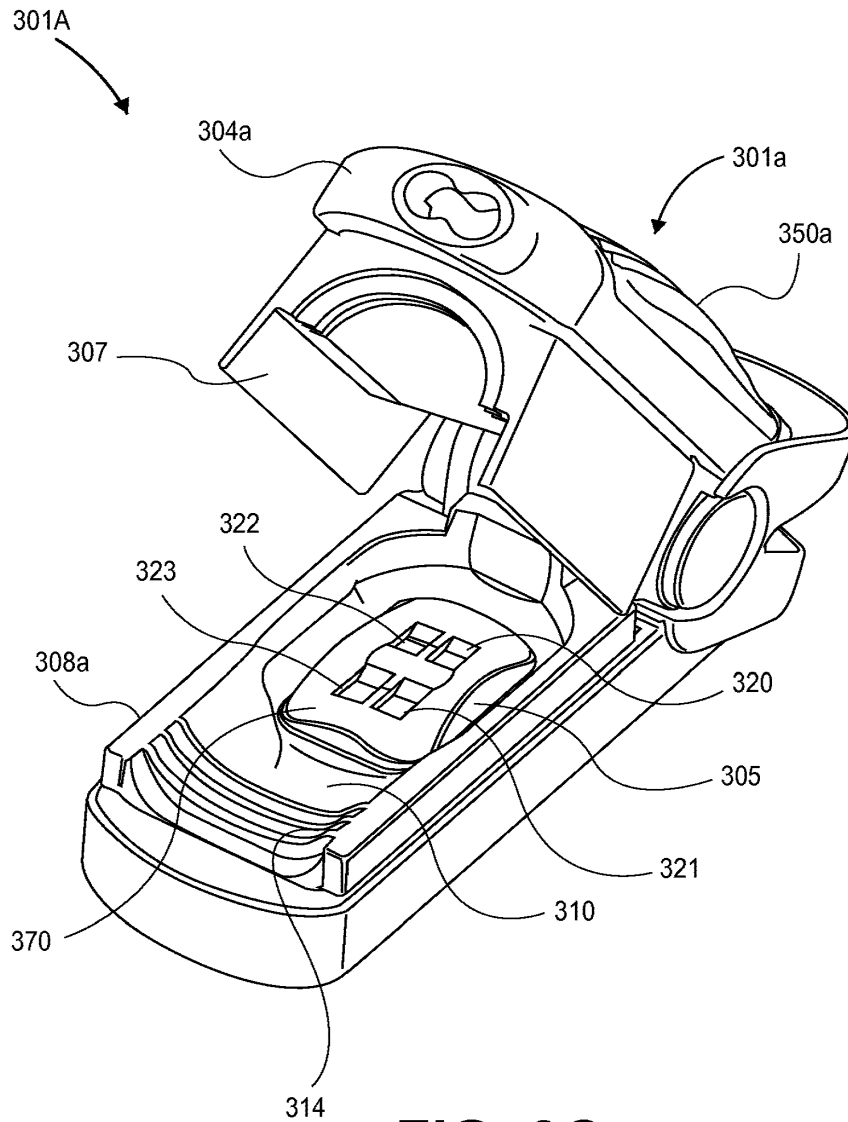


**FIG. 3B**

WO 2010/003134

PCT/US2009/049638

8/43

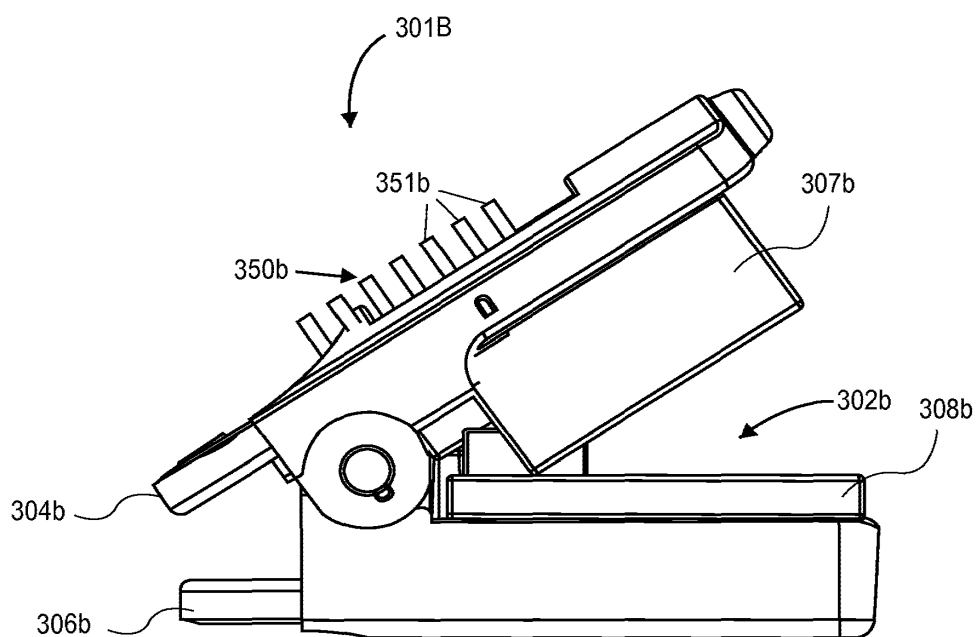


**FIG. 3C**

WO 2010/003134

PCT/US2009/049638

9/43



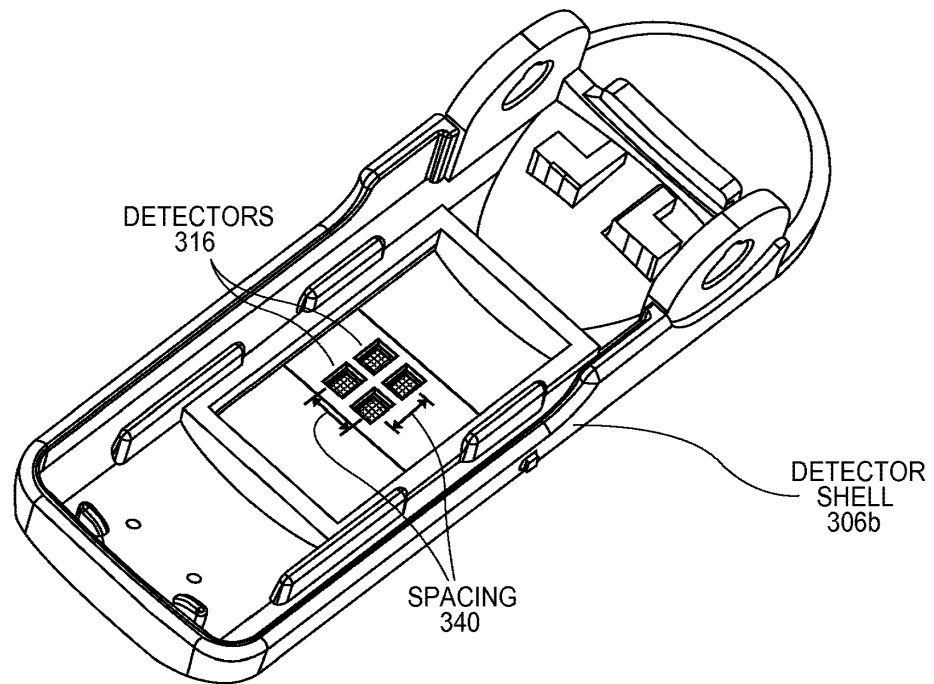
**FIG. 3D**



WO 2010/003134

PCT/US2009/049638

10/43



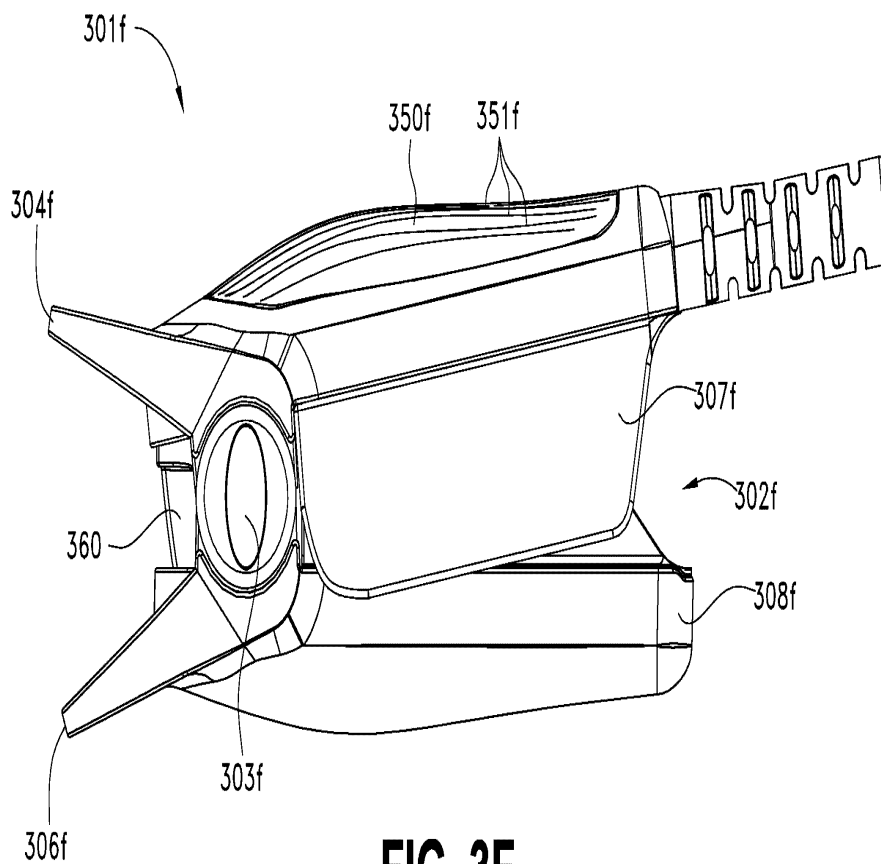
**FIG. 3E**

CX-1623

WO 2010/003134

11 / 43

PCT/US2009/049638

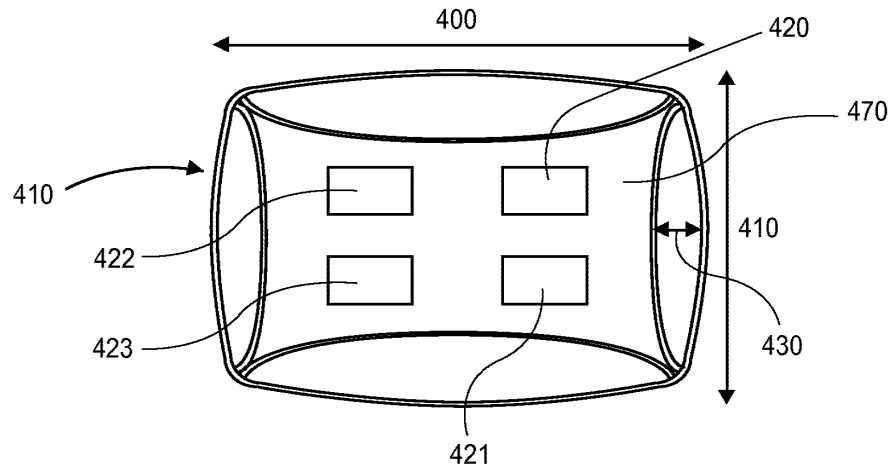


**FIG. 3F**

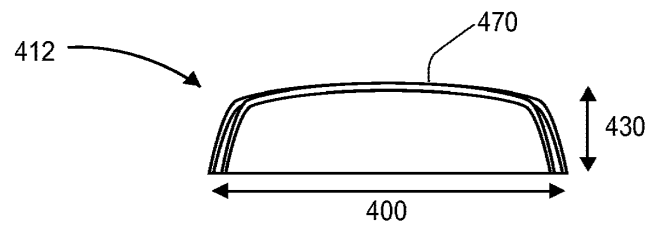
WO 2010/003134

PCT/US2009/049638

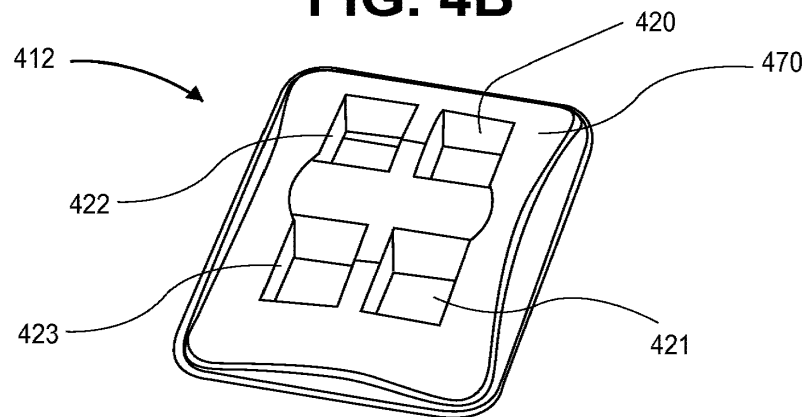
12/43



**FIG. 4A**

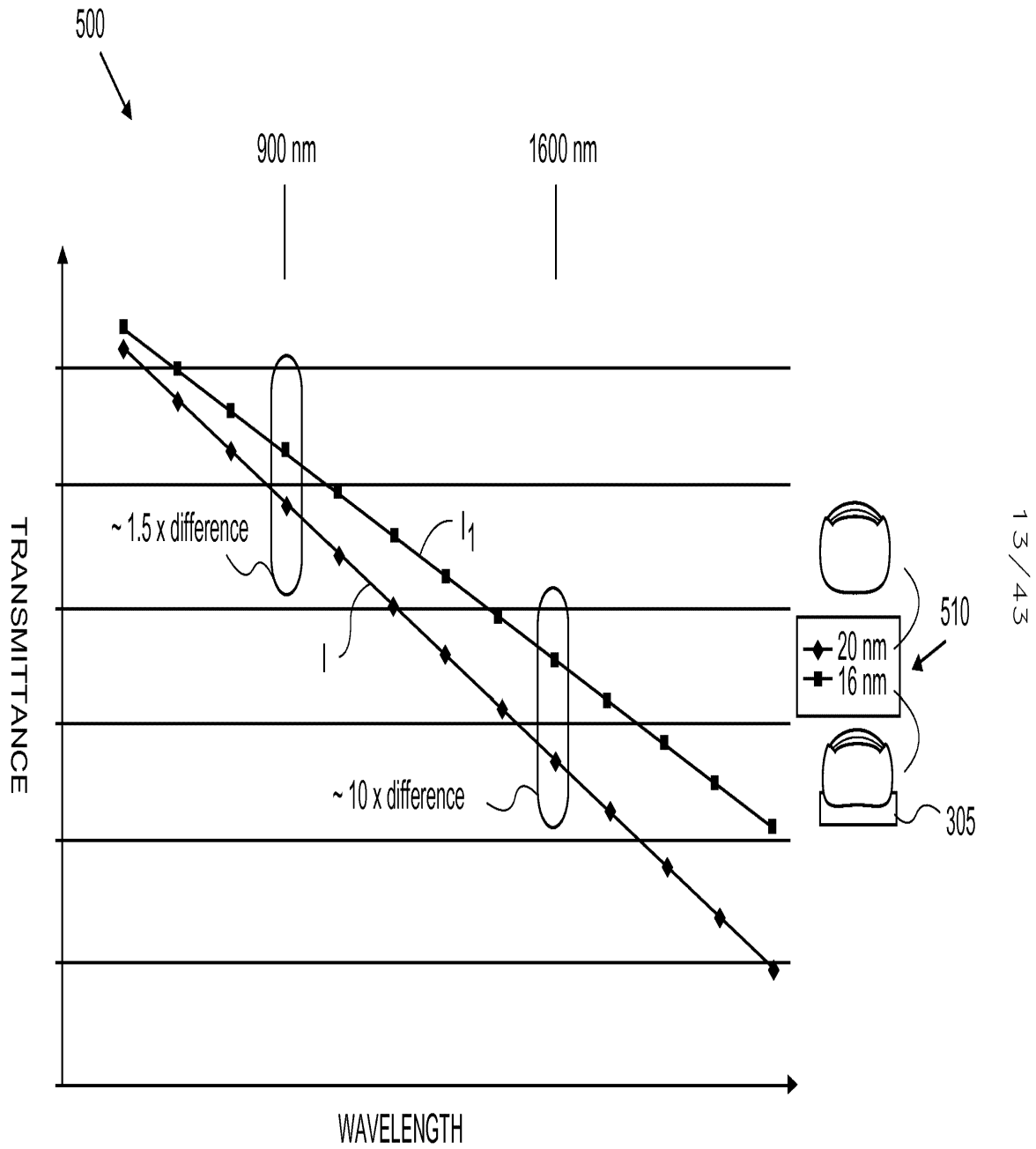


**FIG. 4B**



**FIG. 4C**

CX-1623



WO 2010/003134

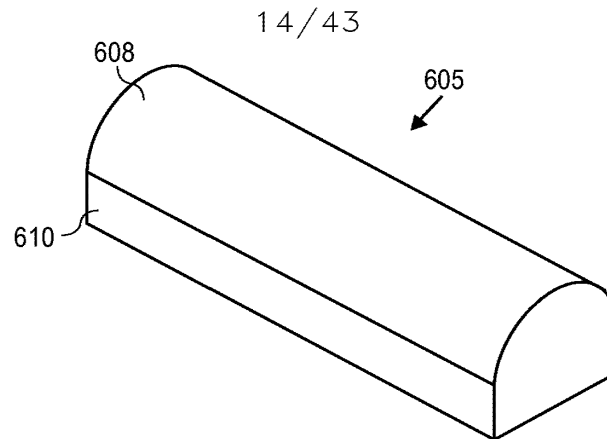
13/43

PCT/US2009/049638

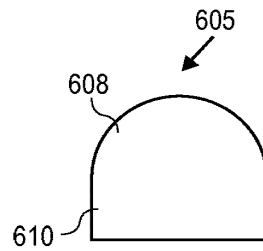
FIG. 5

WO 2010/003134

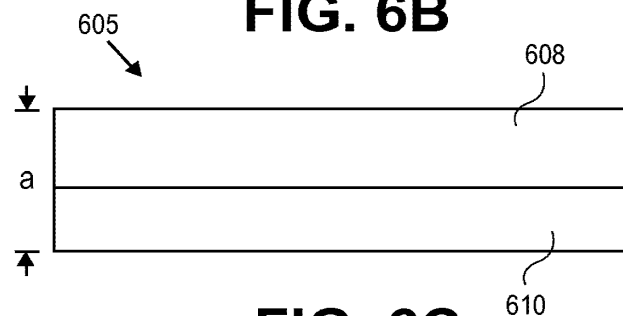
PCT/US2009/049638



**FIG. 6A**



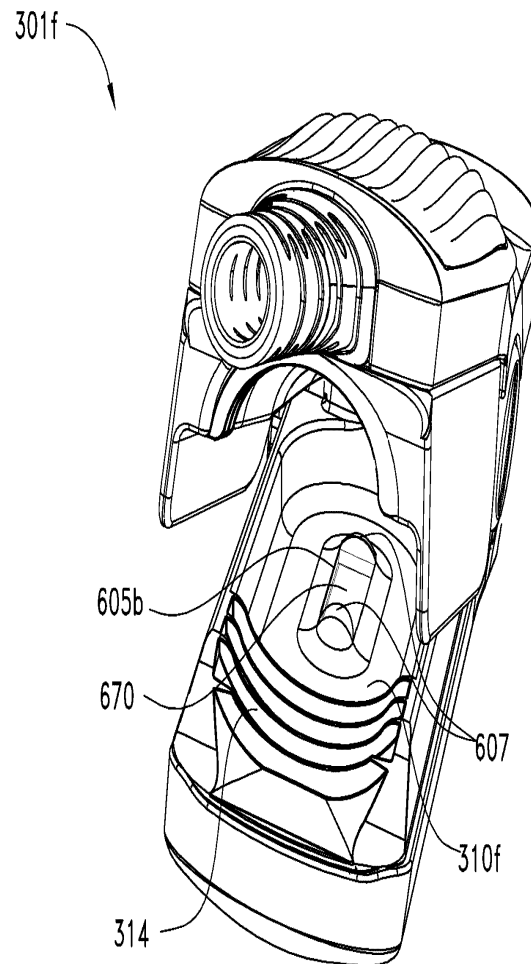
**FIG. 6B**



**FIG. 6C**



**FIG. 6D**

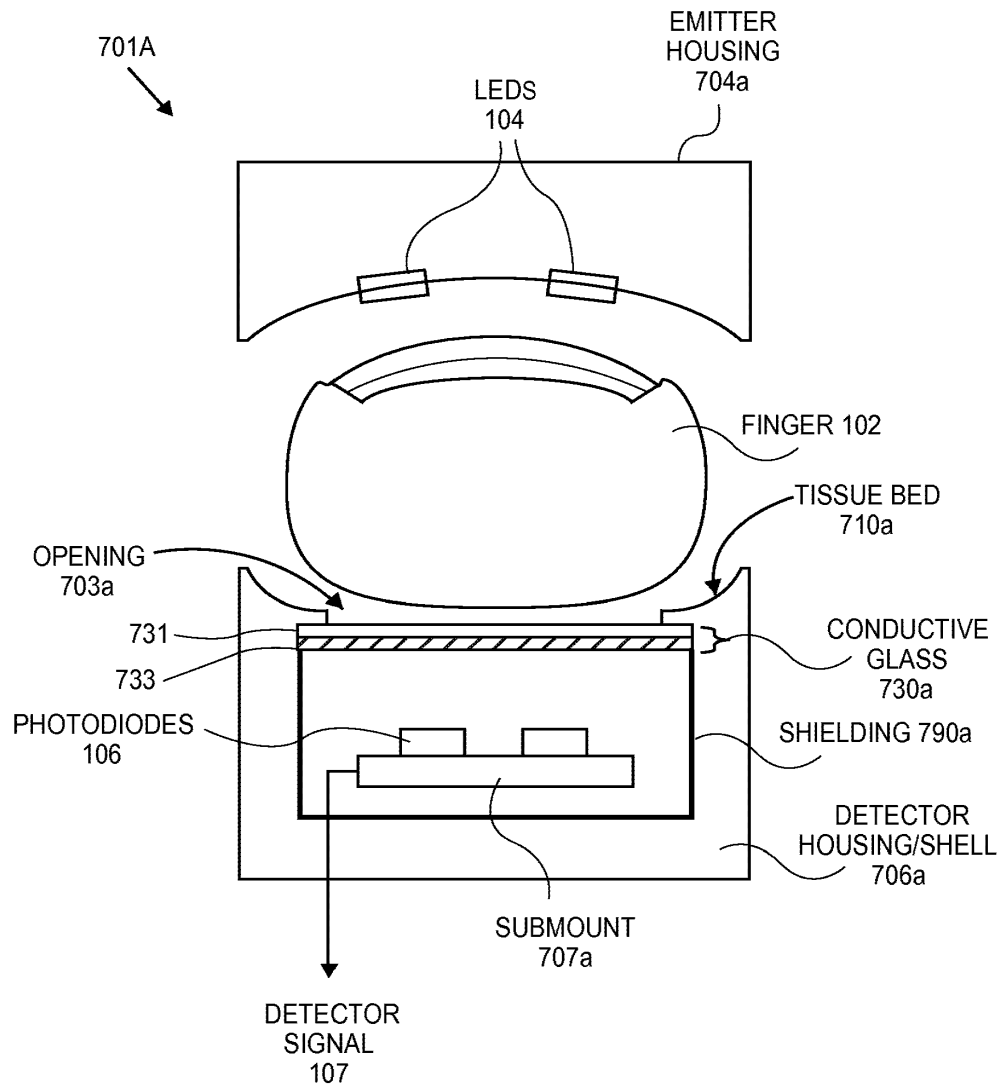


**FIG. 6E**

WO 2010/003134

PCT/US2009/049638

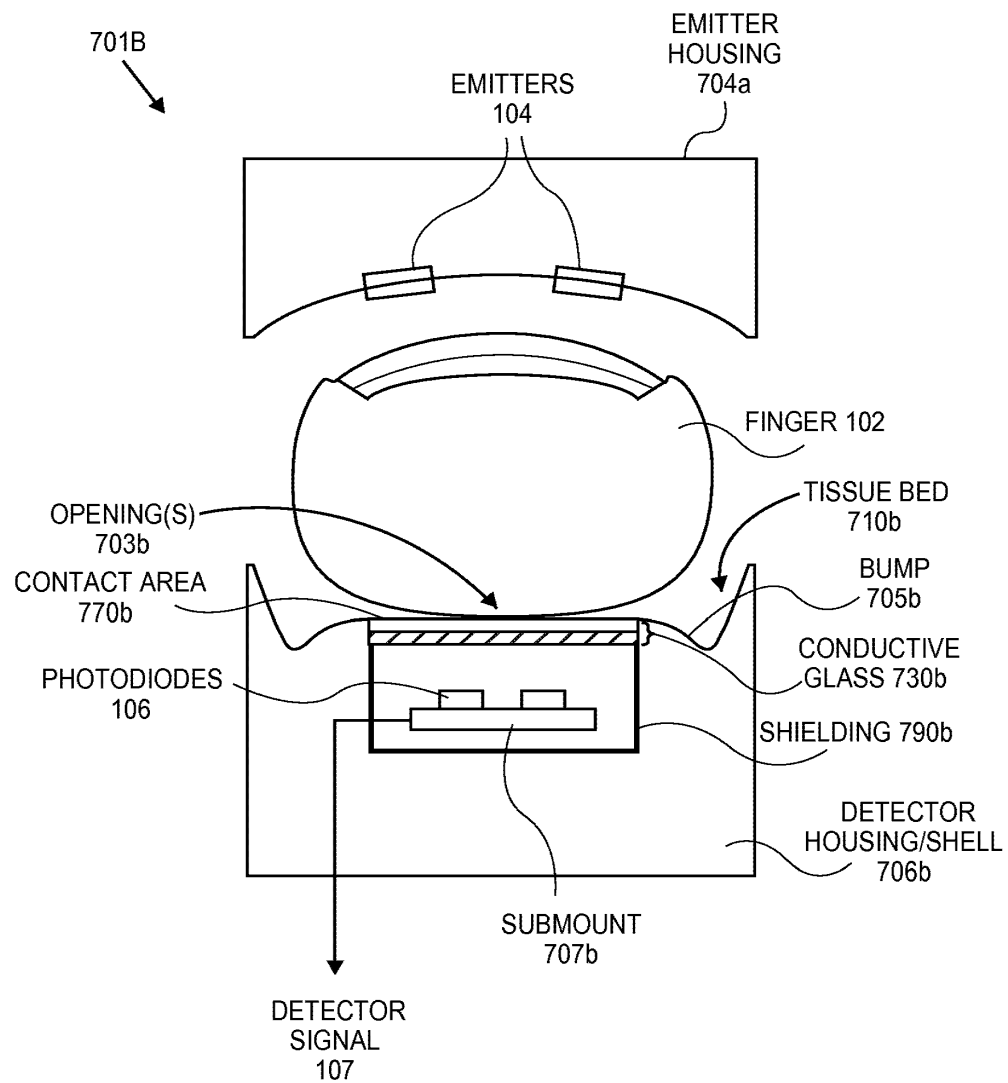
16/43

**FIG. 7A**

WO 2010/003134

PCT/US2009/049638

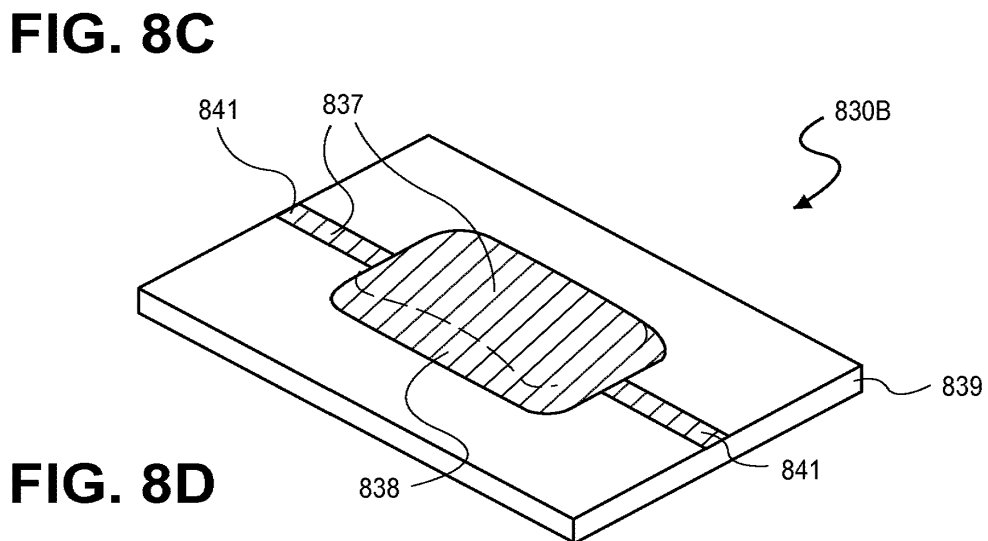
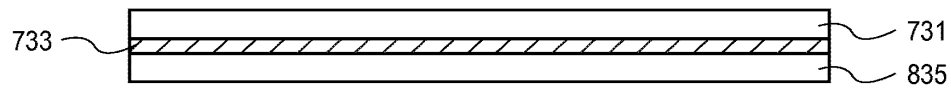
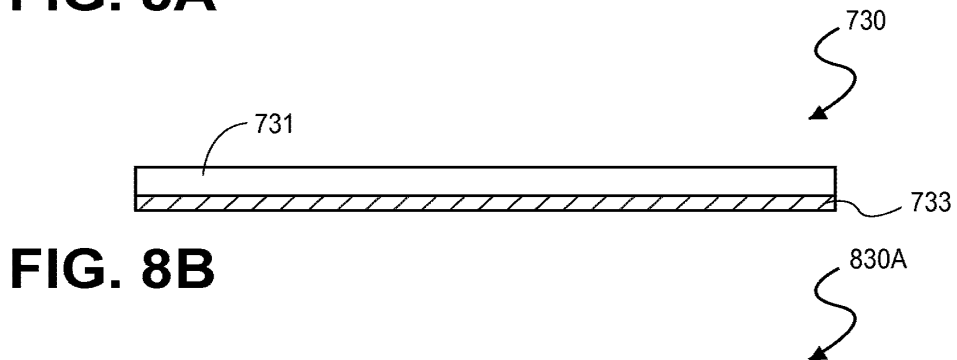
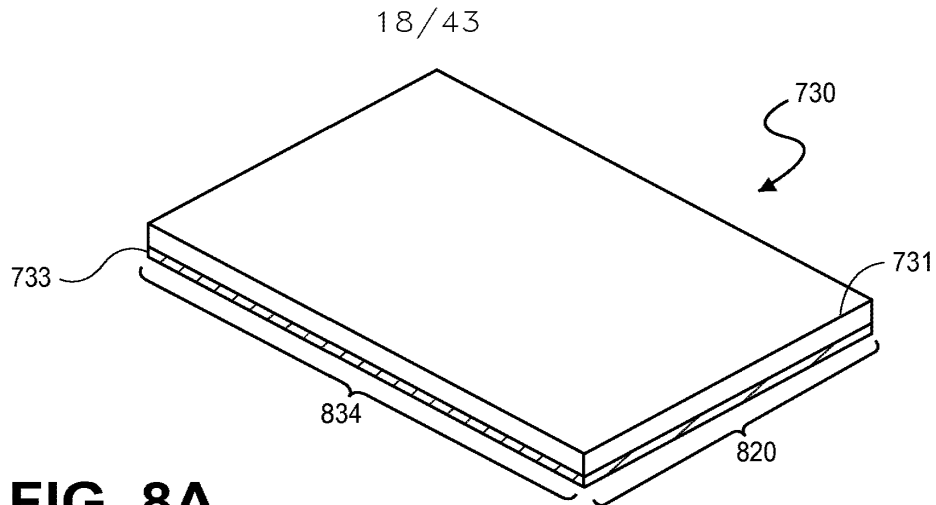
17/43

**FIG. 7B**



WO 2010/003134

PCT/US2009/049638



CX-1623

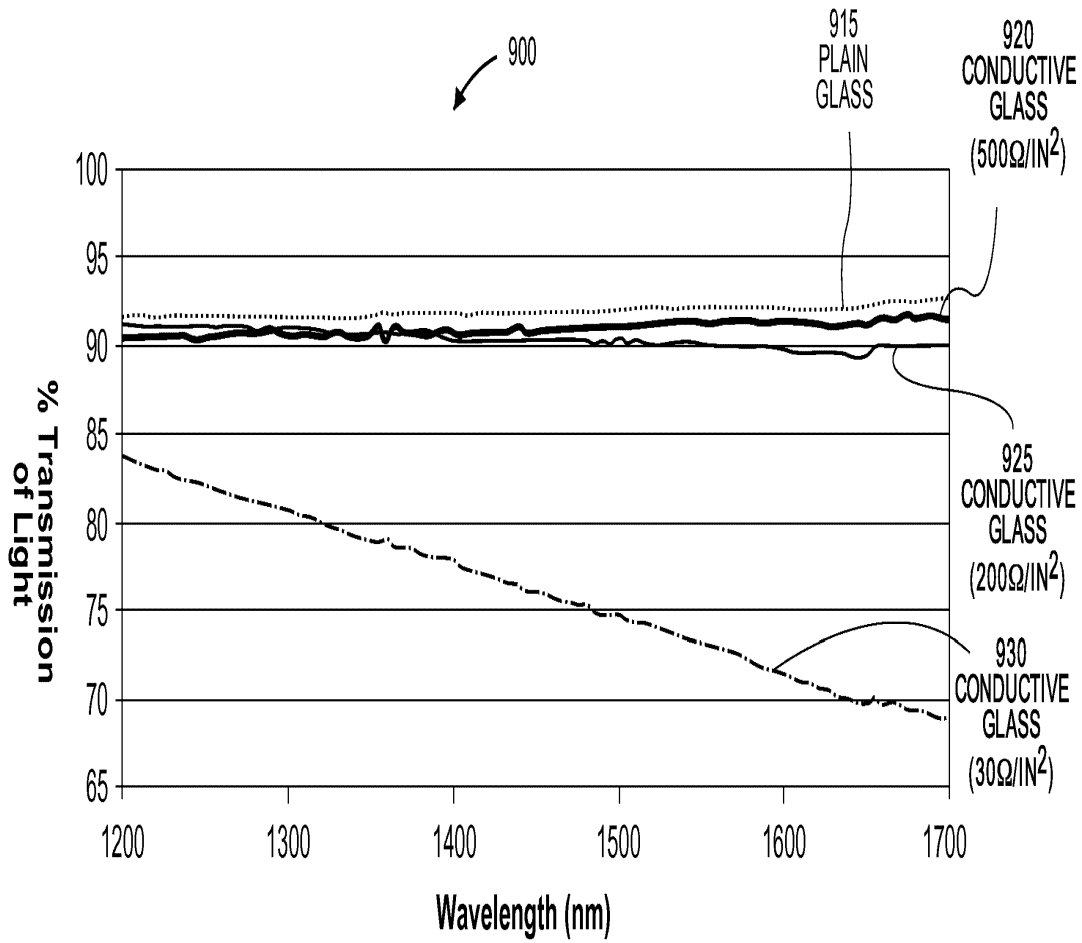


FIG. 9

WO 2010/003134

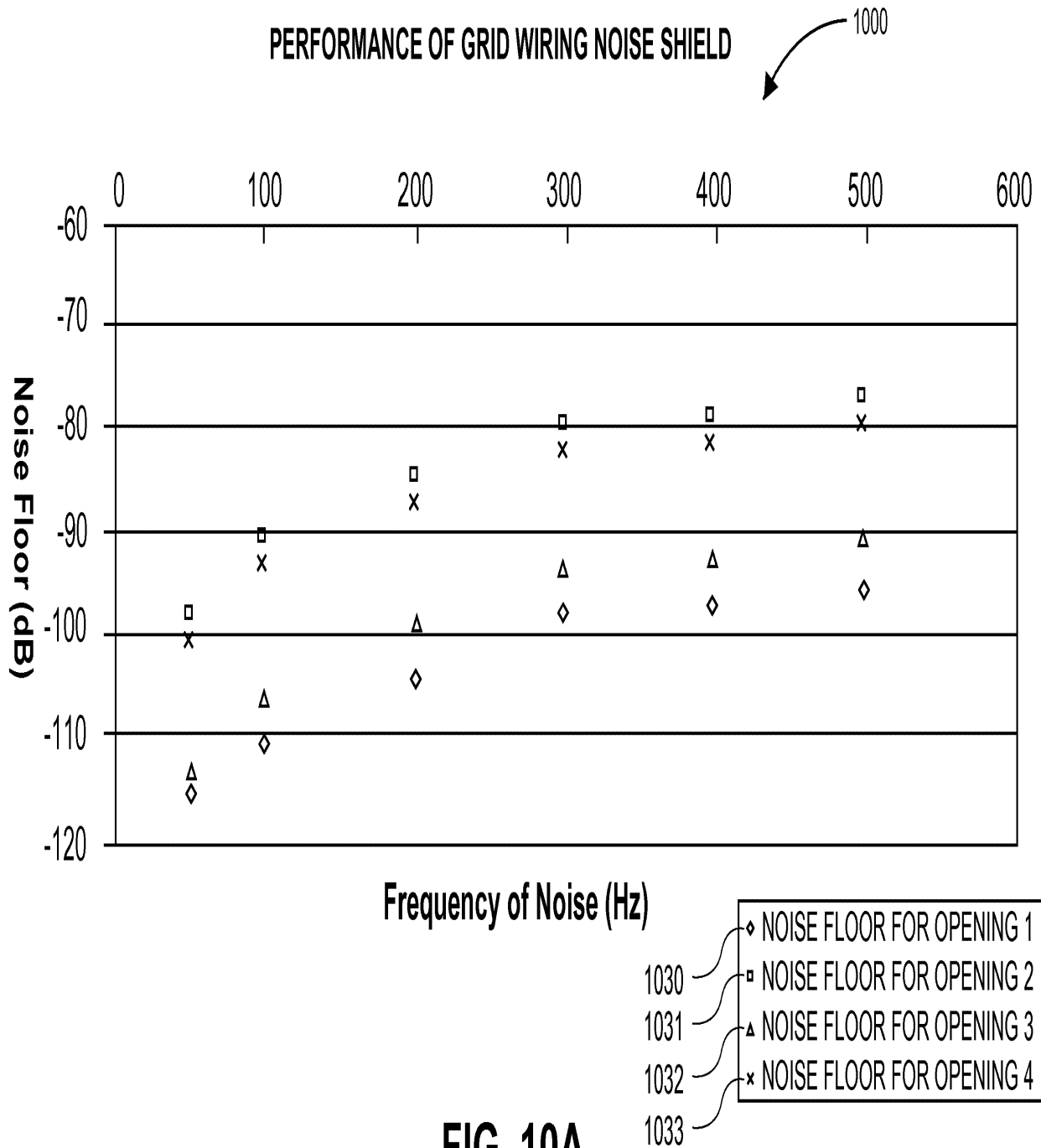
19 / 43

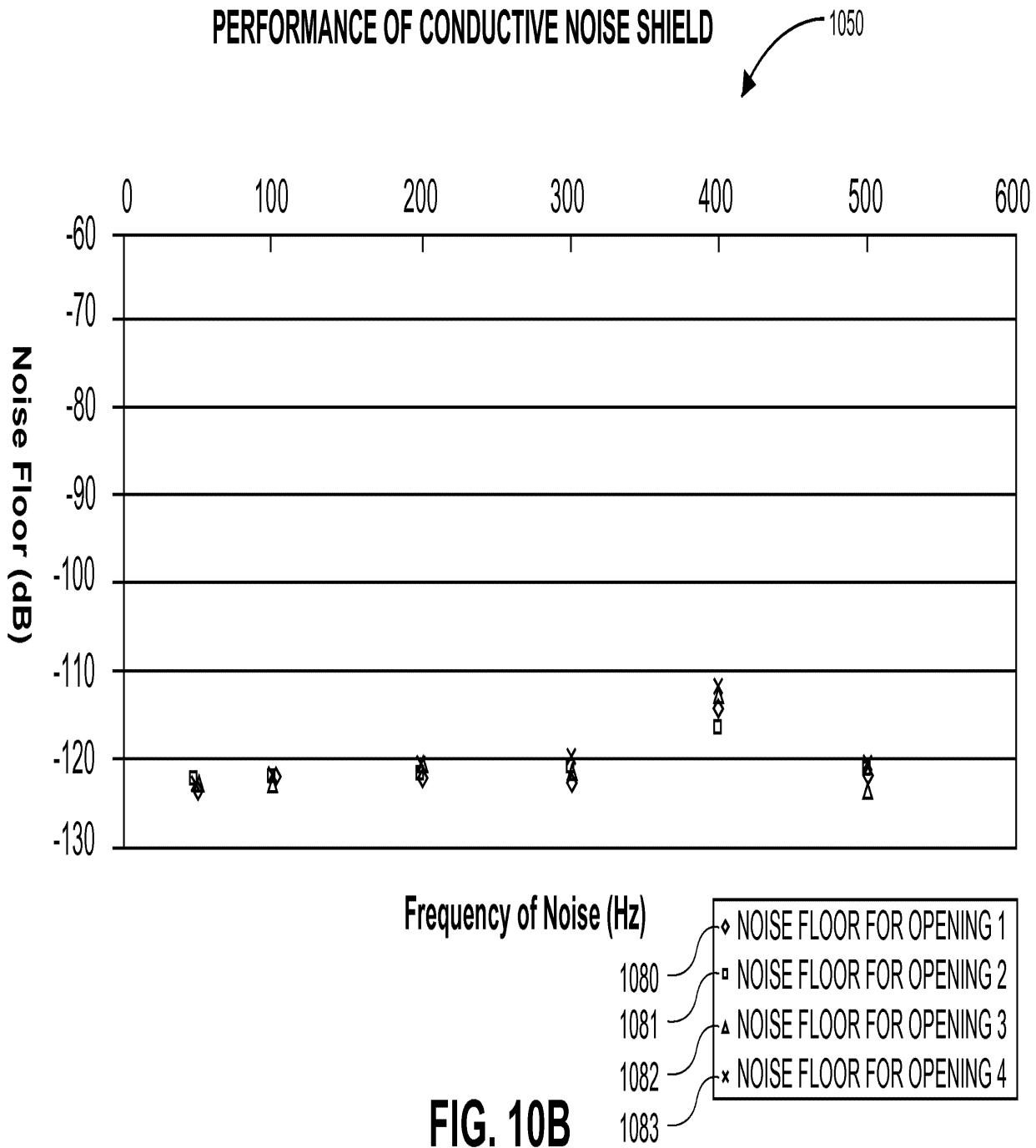
PCT/US2009/049638

WO 2010/003134

20 / 43

PCT/US2009/049638



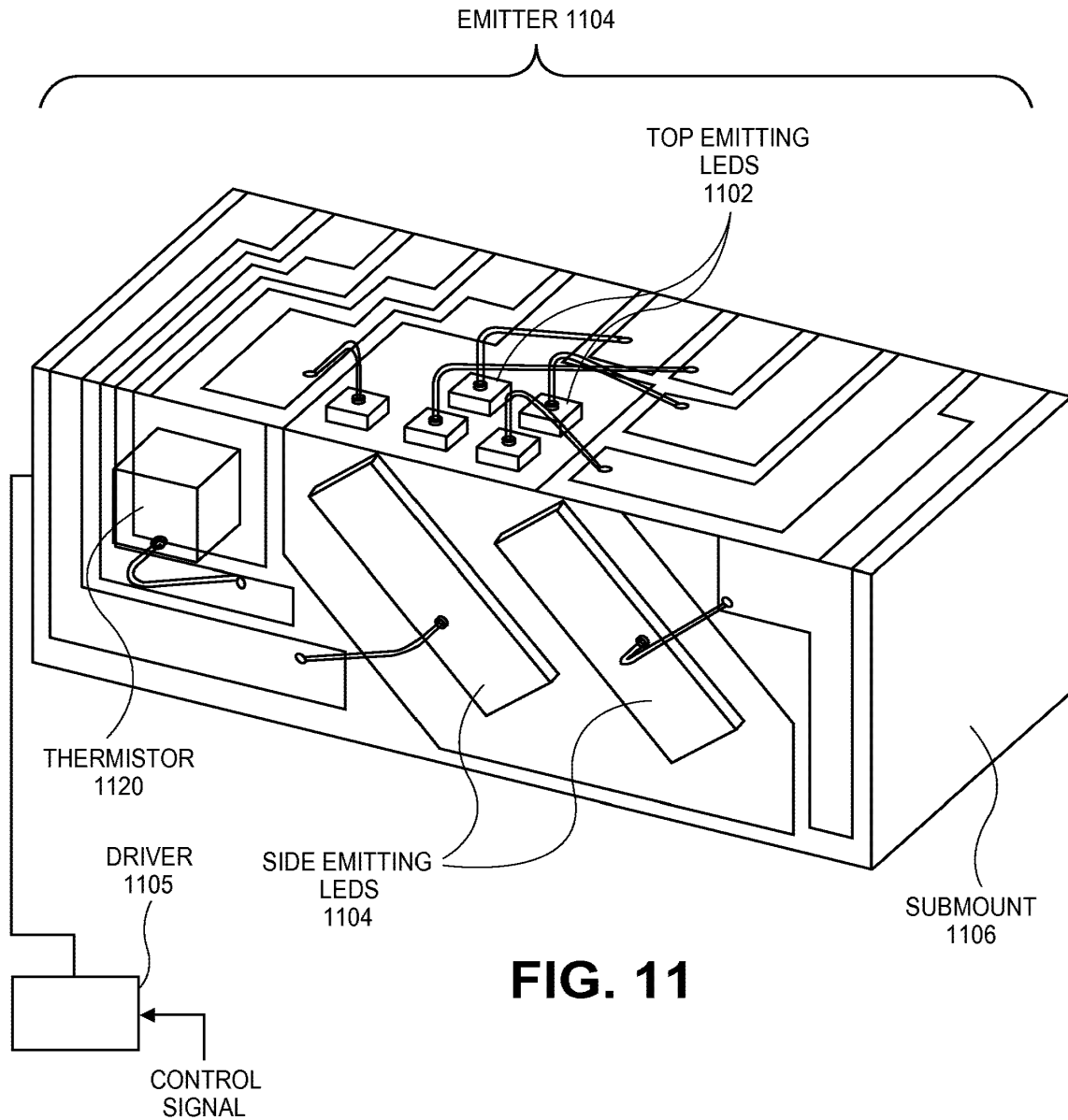


**FIG. 10B**

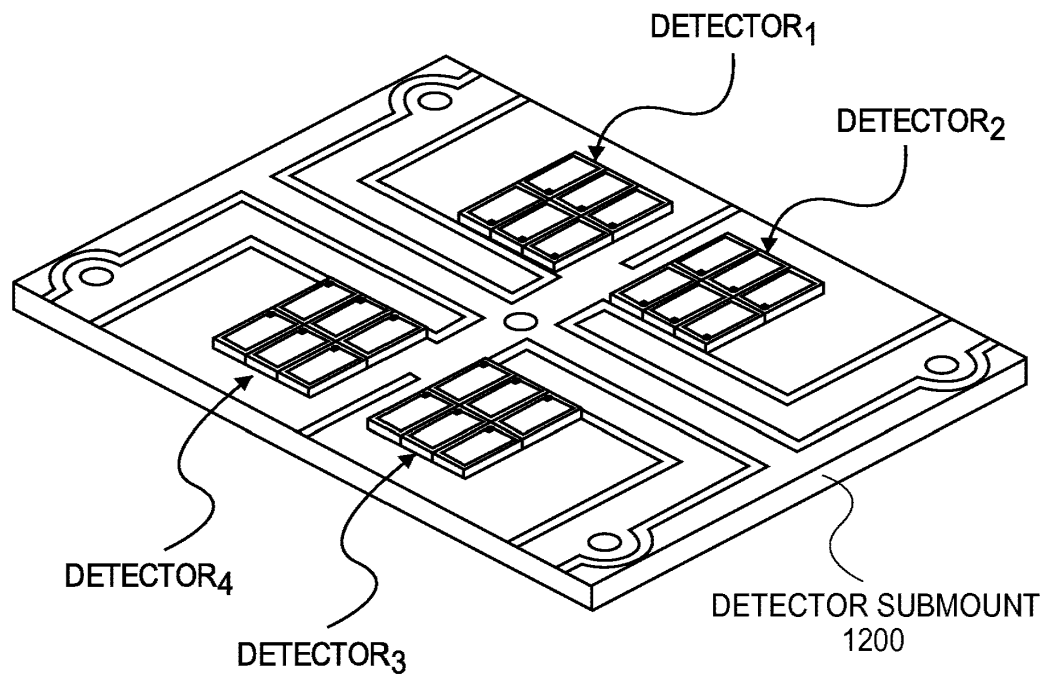
WO 2010/003134

PCT/US2009/049638

22/43



23/43

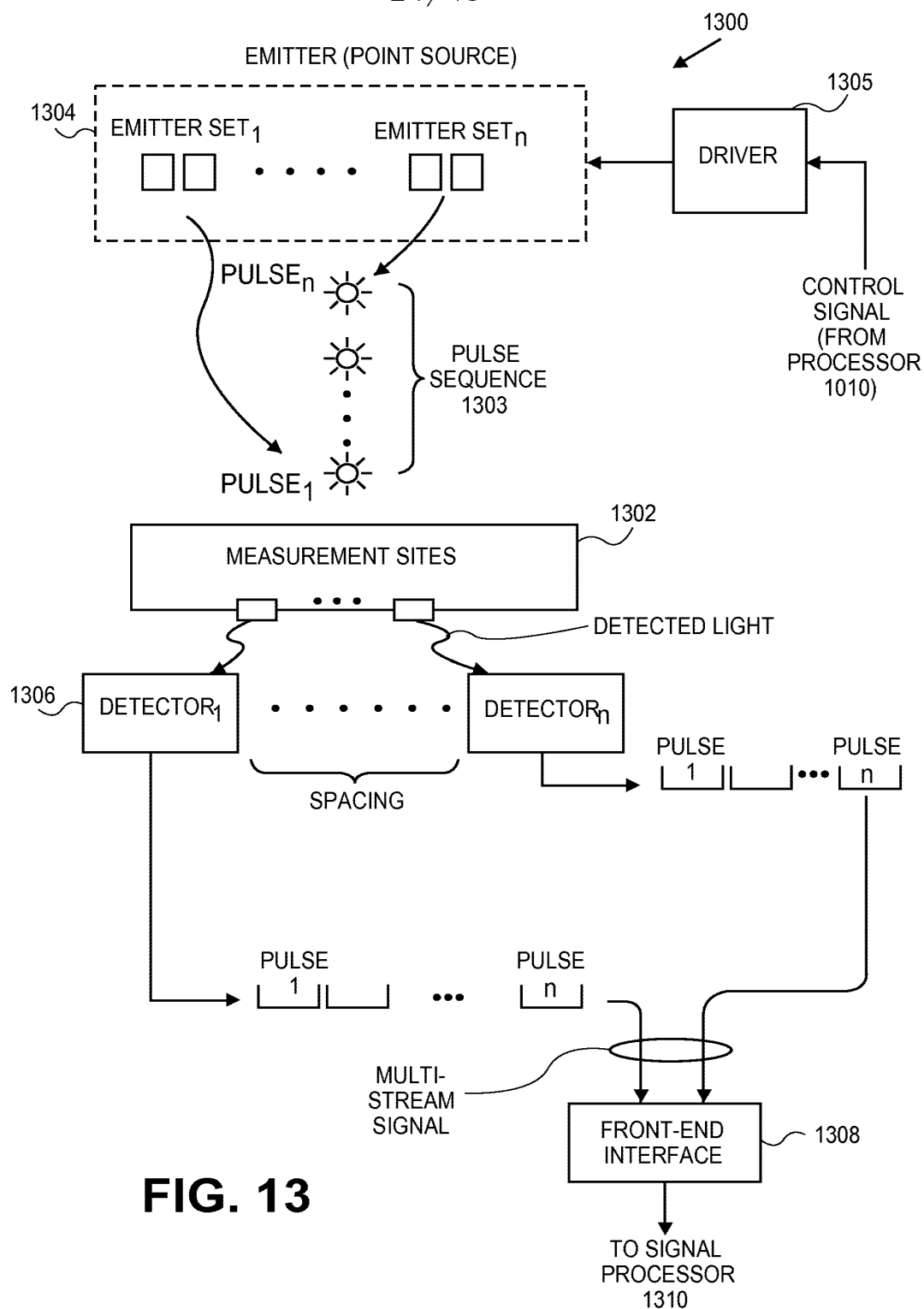


**FIG. 12**

WO 2010/003134

PCT/US2009/049638

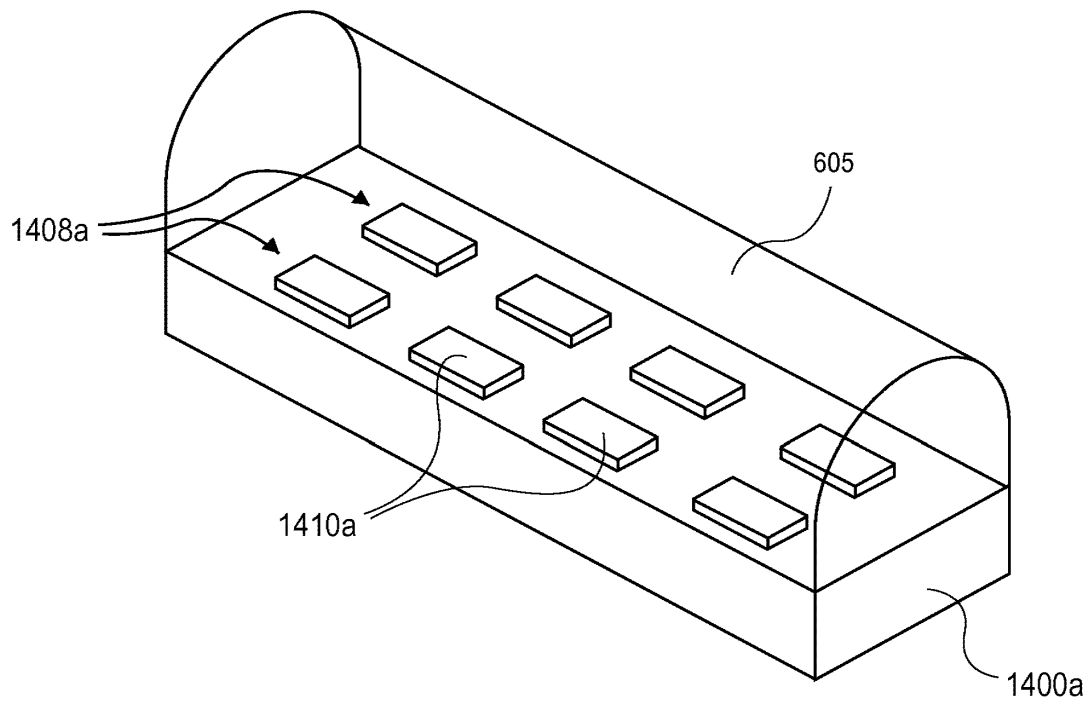
24/43

**FIG. 13**

WO 2010/003134

PCT/US2009/049638

25/43



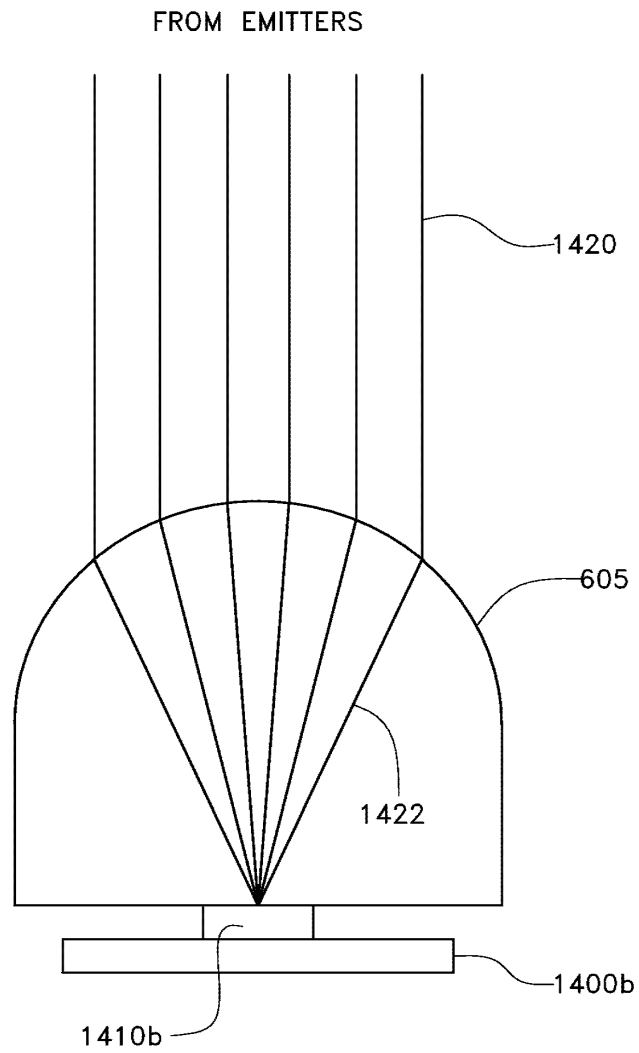
**FIG. 14A**



WO 2010/003134

PCT/US2009/049638

26/43

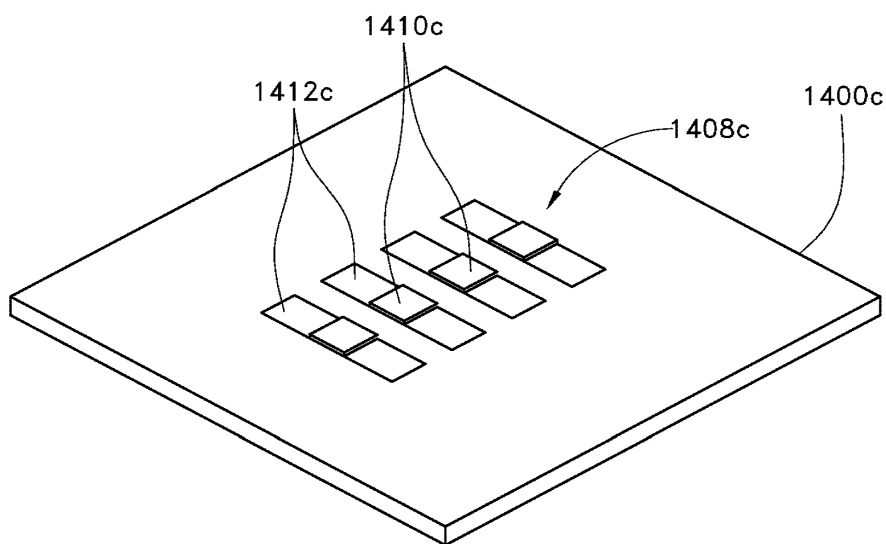


**FIG. 14B**

WO 2010/003134

PCT/US2009/049638

27/43

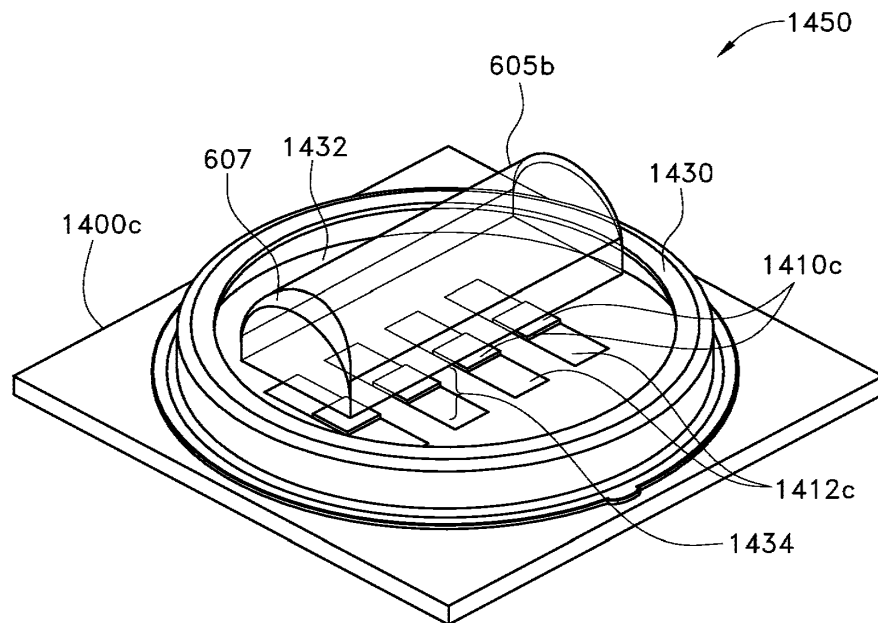


**FIG. 14C**

WO 2010/003134

PCT/US2009/049638

28/43

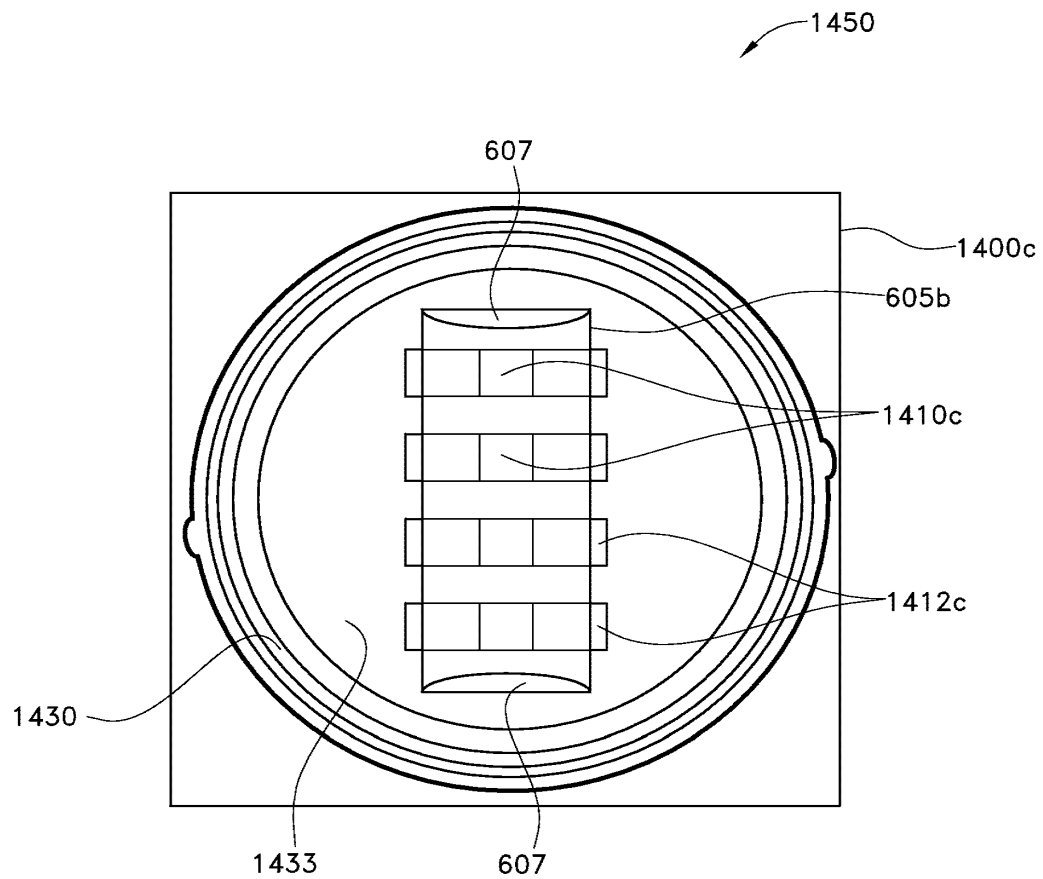


**FIG. 14D**

WO 2010/003134

PCT/US2009/049638

29/43

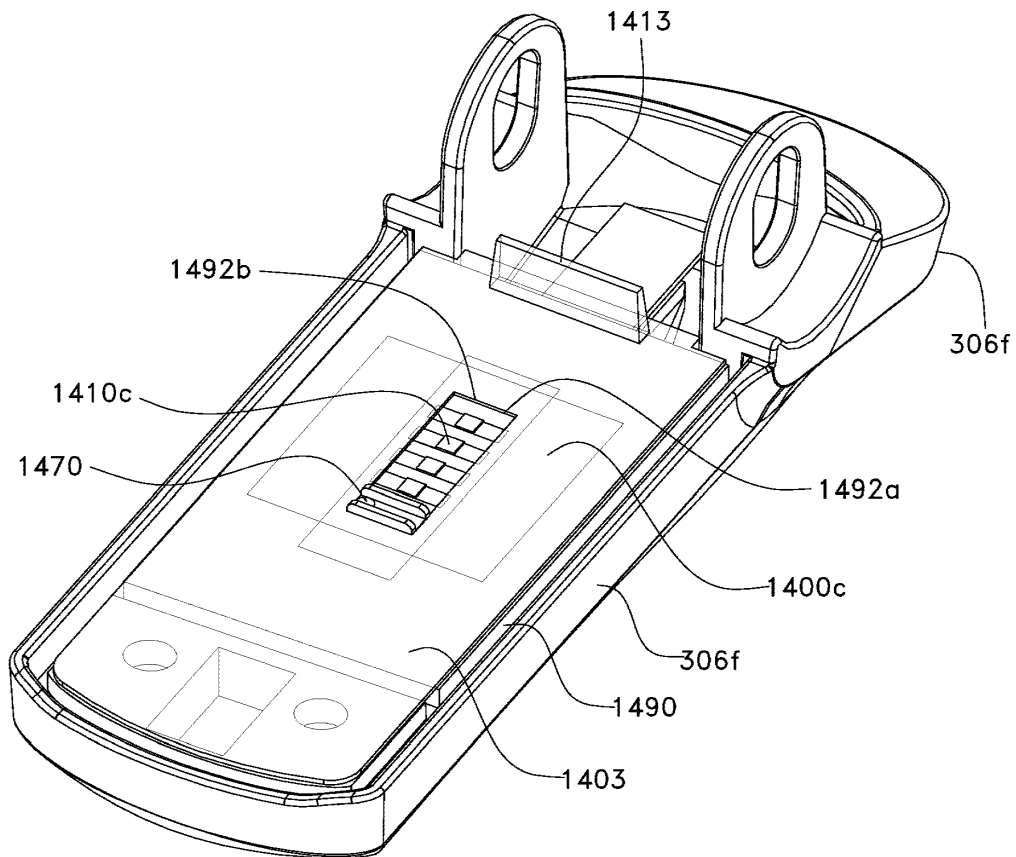


**FIG. 14E**

WO 2010/003134

PCT/US2009/049638

30/43

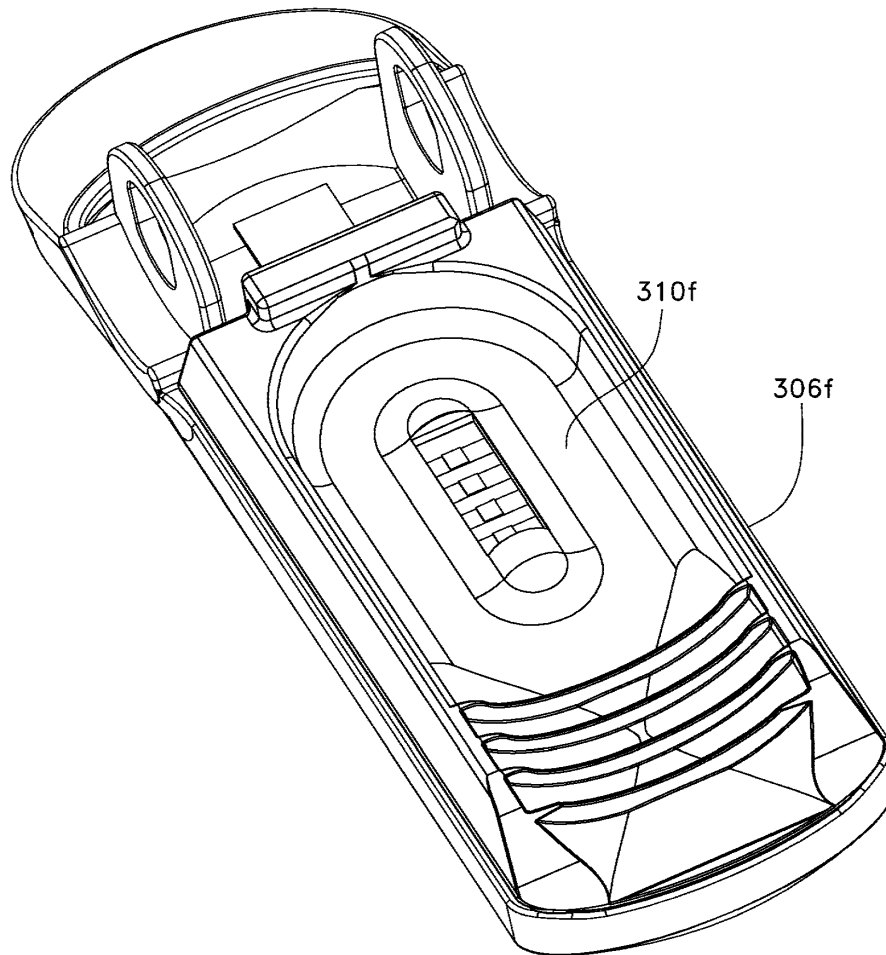


**FIG. 14F**

WO 2010/003134

PCT/US2009/049638

31/43

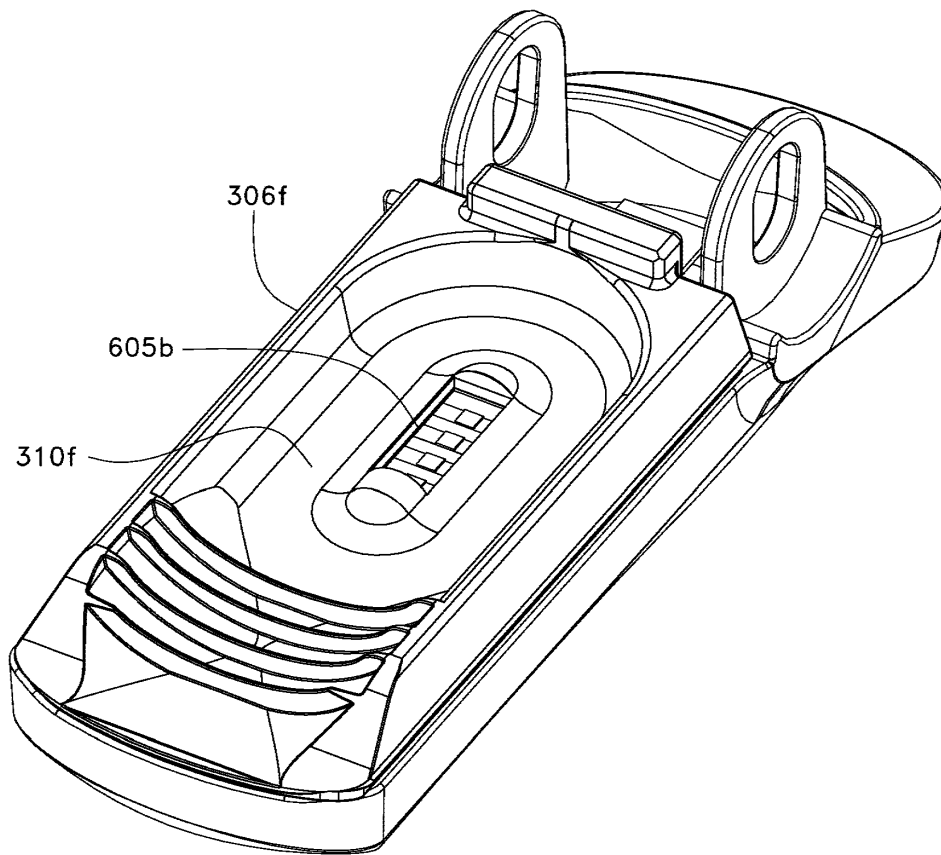


**FIG. 14G**

WO 2010/003134

PCT/US2009/049638

32/43

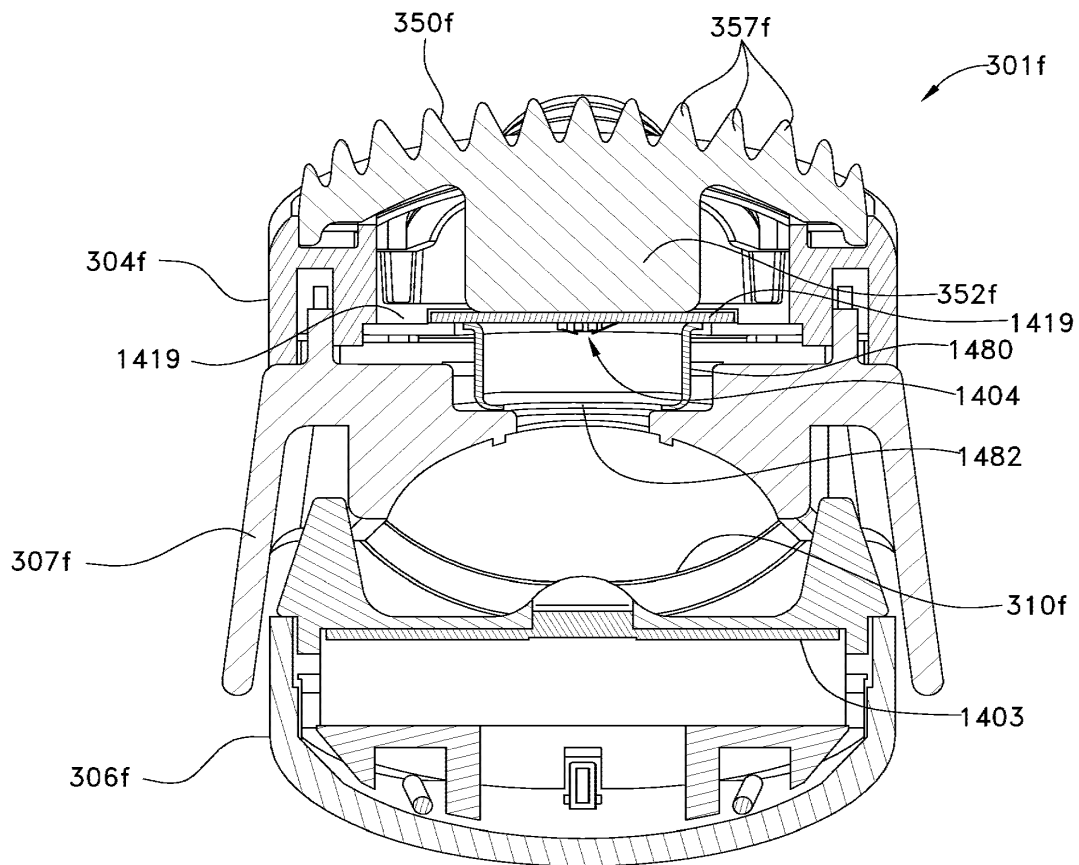


**FIG. 14H**

WO 2010/003134

PCT/US2009/049638

33/43



**FIG. 14I**



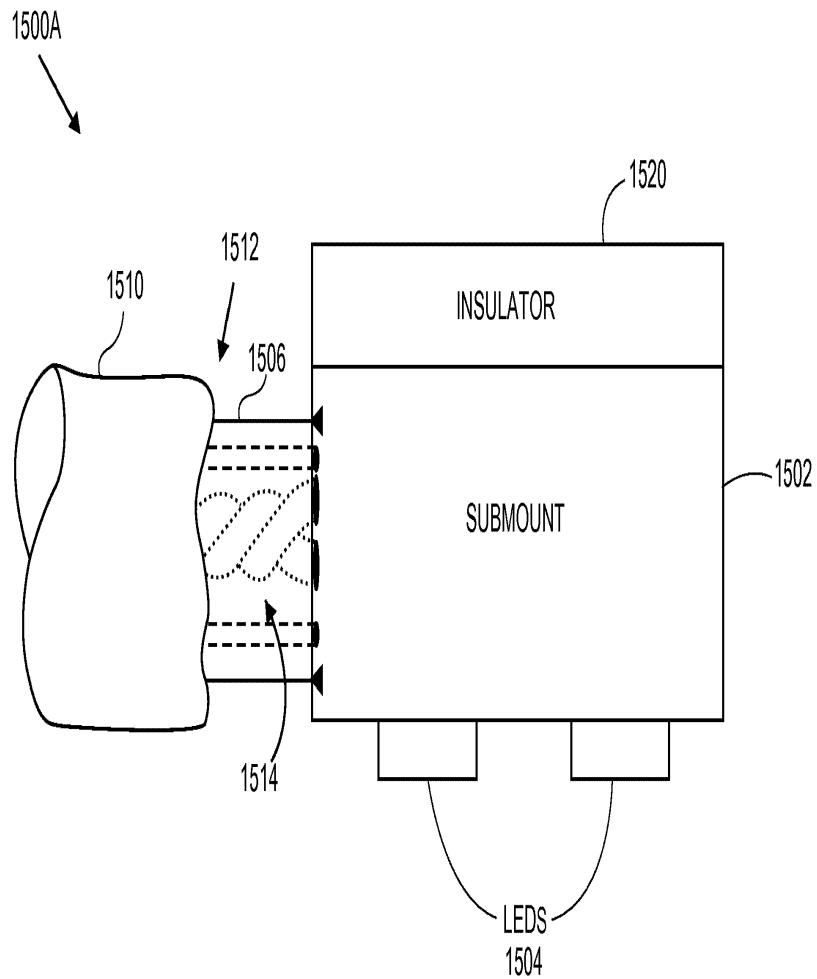


FIG. 15A

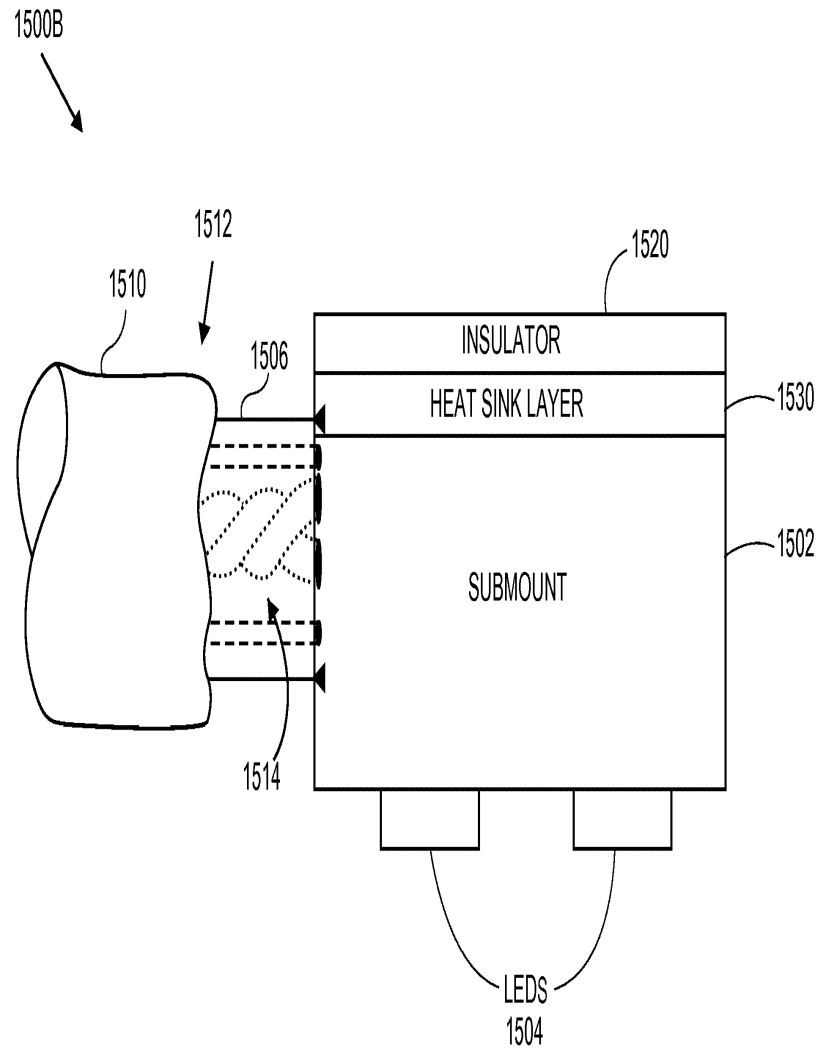
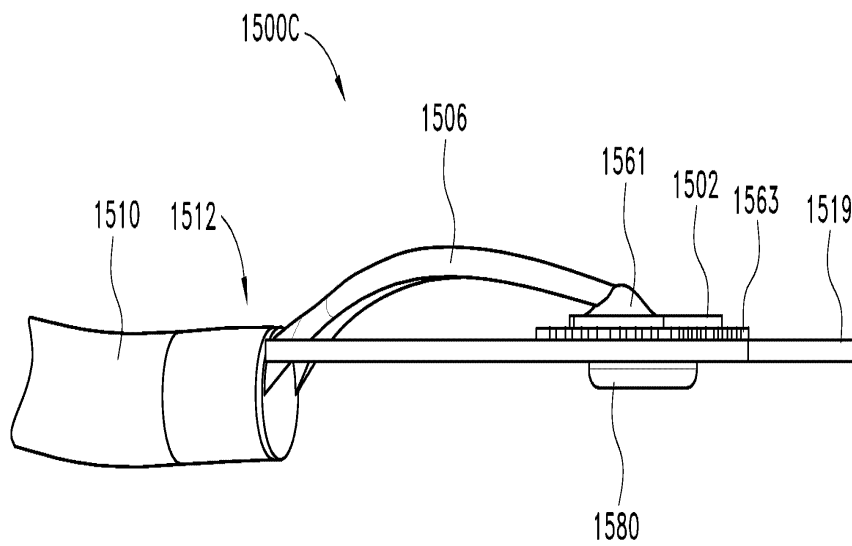


FIG. 15B

CX-1623

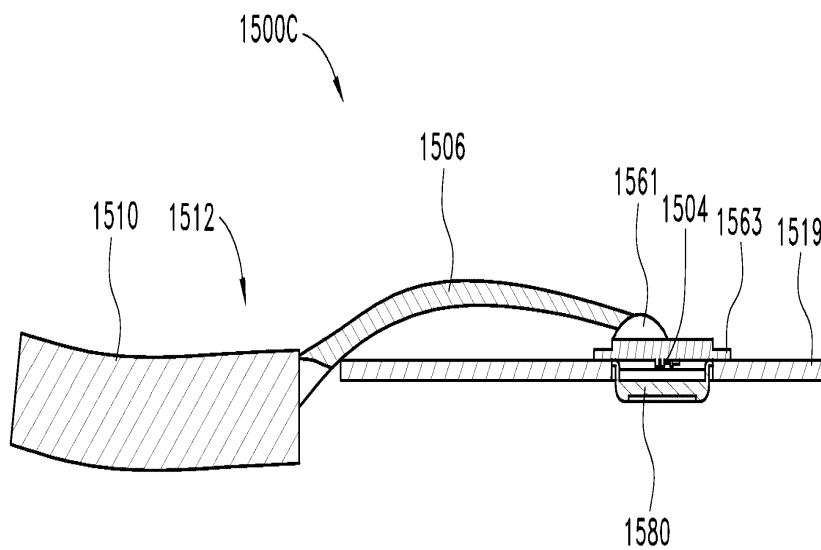
WO 2010/003134

36 / 43



**FIG. 15C**

PCT/US2009/049638

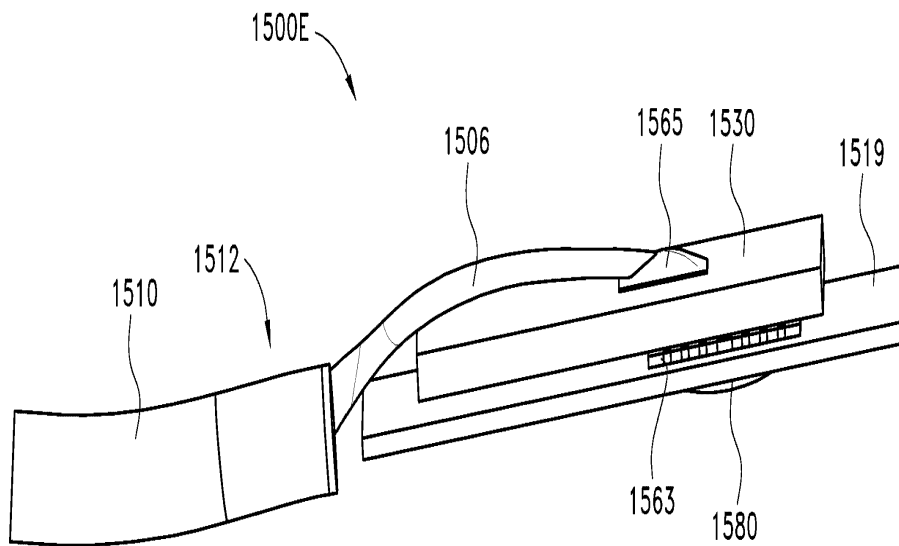


**FIG. 15D**

CX-1623

WO 2010/003134

38 / 43



**FIG. 15E**

PCT/US2009/049638

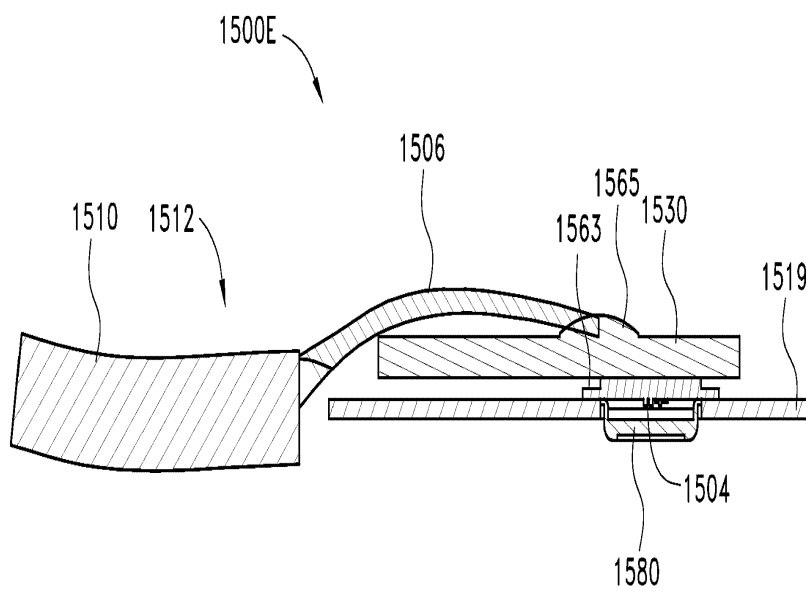
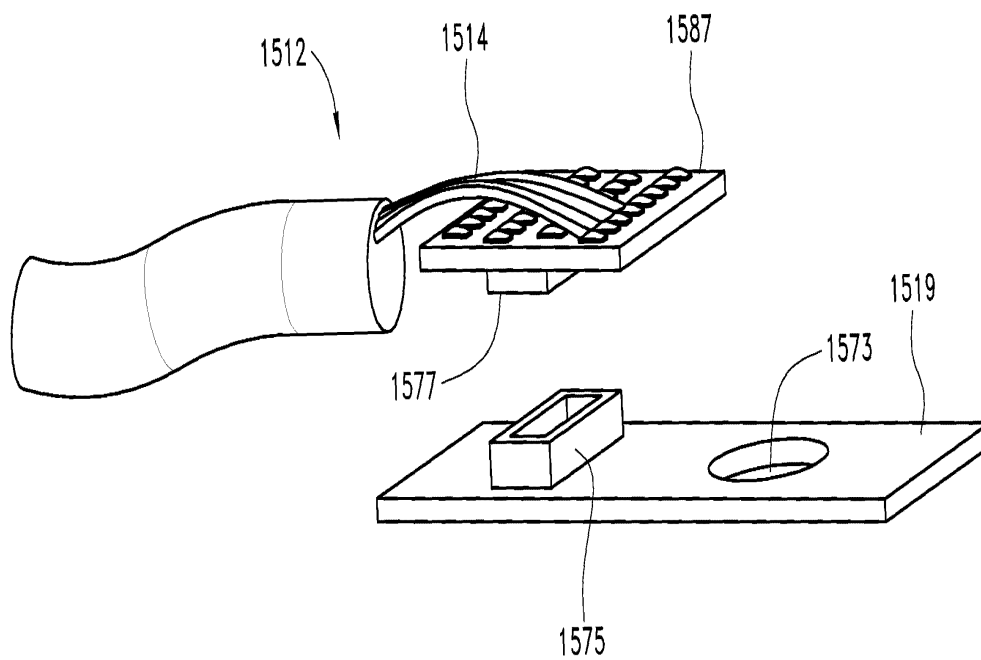


FIG. 15F

CX-1623

WO 2010/003134

40 / 43

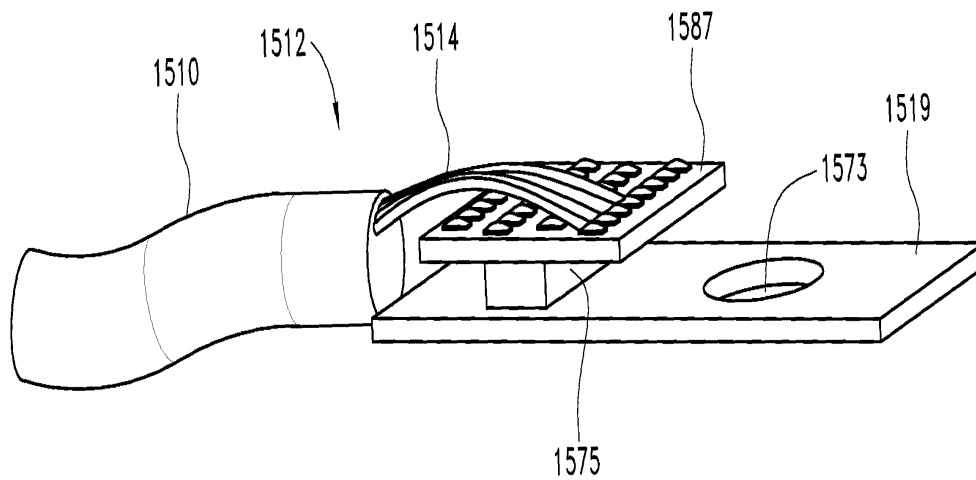


**FIG. 15G**

PCT/US2009/049638

CX-1623

WO 2010/003134



41 / 43

**FIG. 15H**

PCT/US2009/049638



CX-1623

WO 2010/003134

42 / 43

PCT/US2009/049638

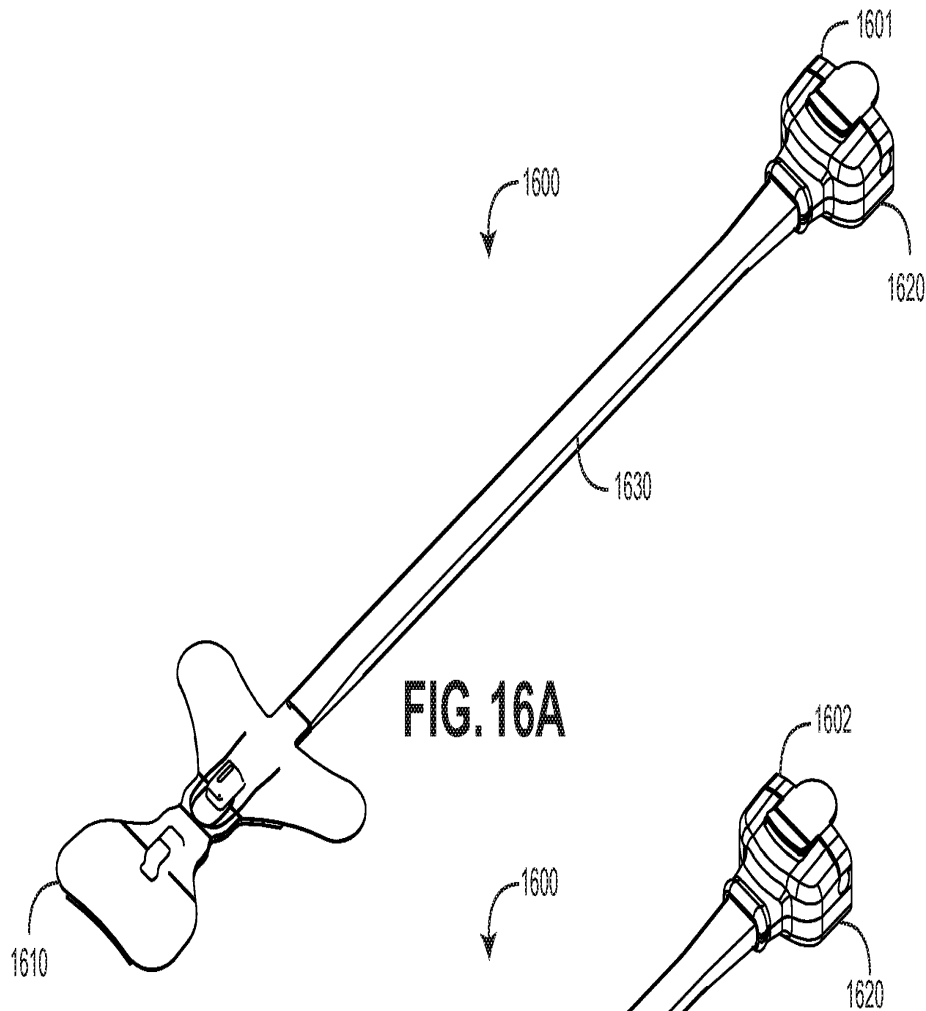


FIG. 16A

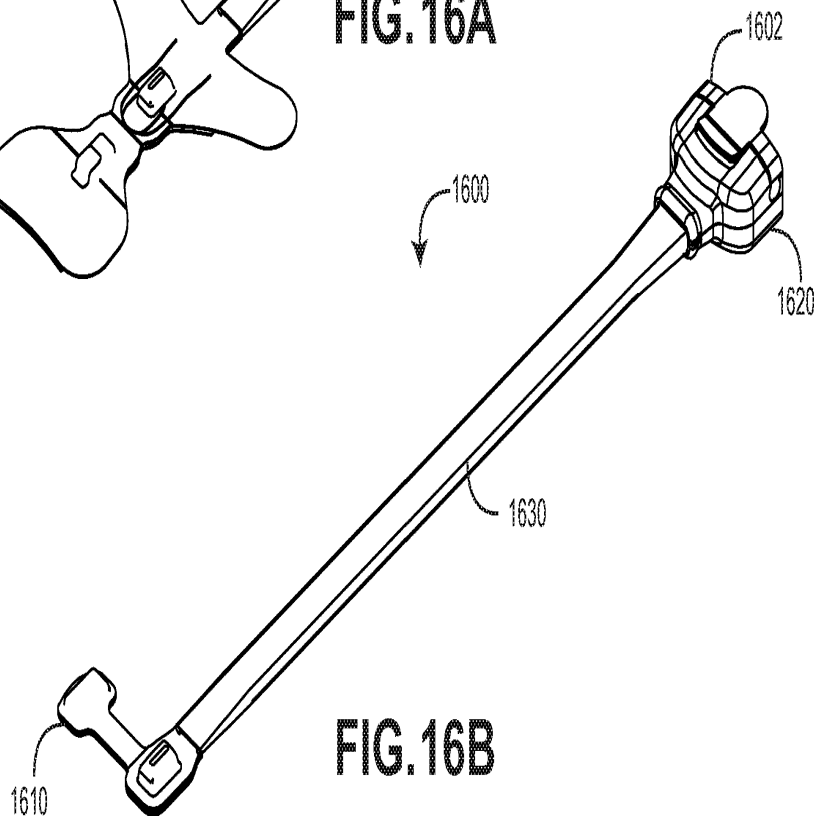
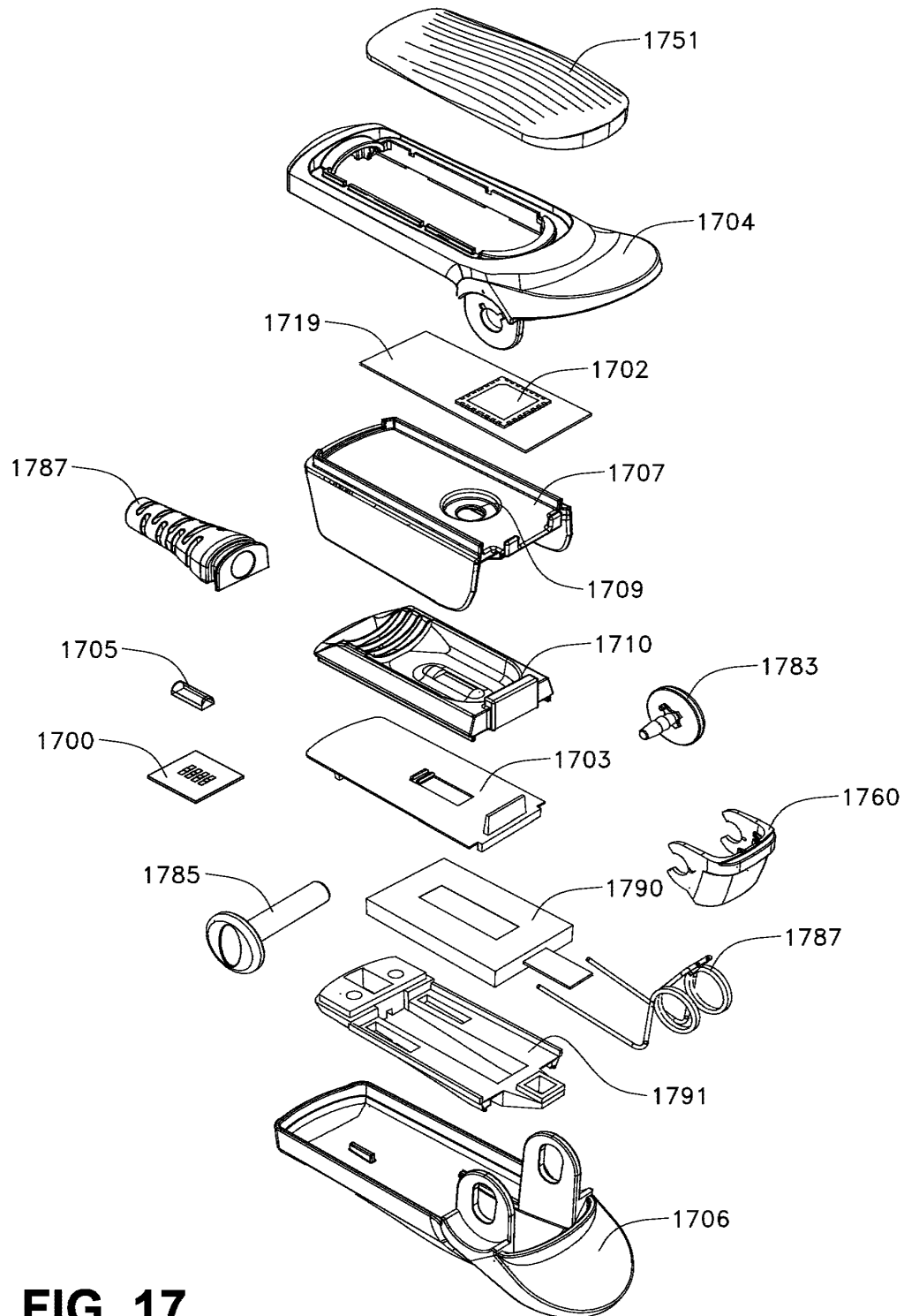


FIG. 16B

WO 2010/003134

PCT/US2009/049638

43/43



**FIG. 17**

CX-1623

Electronic Acknowledgement Receipt	
<b>EFS ID:</b>	33036285
<b>Application Number:</b>	14981290
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9573
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	64735
<b>Filer:</b>	Scott Cromar/Christina Gaul
<b>Filer Authorized By:</b>	Scott Cromar
<b>Attorney Docket Number:</b>	MASCER.002C2
<b>Receipt Date:</b>	28-JUN-2018
<b>Filing Date:</b>	28-DEC-2015
<b>Time Stamp:</b>	15:26:05
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	no
------------------------	----

**File Listing:**

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Response_MASCER002C2.pdf	31515 991e72732f97c785e38aa091948872e9d2b626f9	yes	4

CX-1623

	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Response to Election / Restriction Filed		1	1	
	Claims		2	2	
	Applicant Arguments/Remarks Made in an Amendment		3	4	
Warnings:					
Information:					
2		IDS_MASCER002C2.pdf	102625	yes	11
			dce4dd84614ae4743b2ec099c359fc6cbee1411d		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Transmittal Letter		1	2	
	Information Disclosure Statement (IDS) Form (SB08)		3	11	
Warnings:					
Information:					
3	Foreign Reference	EP_1518494.PDF	1717734	no	36
			2d0b45ee2b6895195a7759f4da1c1084c58a84b2		
Warnings:					
Information:					
4	Foreign Reference	WO_2001_09589.PDF	2597008	no	61
			13716b71b331a97d8f5afce0cff2af7b17a15f6		
Warnings:					
Information:					
5	Foreign Reference	WO_2010_003134.PDF	4063003	no	108
			c56d458f6a5609f574b9f68c990c03de4dda0693		
Warnings:					
Information:					

CX-1623

6	Non Patent Literature	2016-06-26_OA_002EP.PDF	364421 f5abb6cd5b495a40c8e5ee2301b06612b967ad58	no	9
<b>Warnings:</b>					
<b>Information:</b>					
<b>Total Files Size (in bytes):</b>			8876306		
<p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>          If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>          If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>          If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p>					

CX-1623

PTO/SB/06 (09-11)

Approved for use through 1/31/2014. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

<b>PATENT APPLICATION FEE DETERMINATION RECORD</b> Substitute for Form PTO-875				Application or Docket Number <b>14/981,290</b>		Filing Date <b>12/28/2015</b>		<input type="checkbox"/> To be Mailed		
ENTITY: <input checked="" type="checkbox"/> LARGE <input type="checkbox"/> SMALL <input type="checkbox"/> MICRO										
<b>APPLICATION AS FILED – PART I</b>										
(Column 1)		(Column 2)								
FOR	NUMBER FILED	NUMBER EXTRA			RATE (\$)	FEE (\$)				
<input type="checkbox"/> BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A			N/A					
<input type="checkbox"/> SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A			N/A					
<input type="checkbox"/> EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A			N/A					
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*			X \$ =					
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*			X \$ =					
<input type="checkbox"/> APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).									
<input type="checkbox"/> MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))										
* If the difference in column 1 is less than zero, enter "0" in column 2.					TOTAL					
<b>APPLICATION AS AMENDED – PART II</b>										
(Column 1)		(Column 2)		(Column 3)						
<b>AMENDMENT</b>	<b>06/28/2018</b>	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)			
	Total (37 CFR 1.16(i))	* 8	Minus	** 20	= 0	X \$100 =	0			
	Independent (37 CFR 1.16(h))	* 1	Minus	*** 3	= 0	X \$460 =	0			
	<input type="checkbox"/> Application Size Fee (37 CFR 1.16(s))									
	<input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
					TOTAL ADD'L FEE		<b>0</b>			
(Column 1)		(Column 2)		(Column 3)						
<b>AMENDMENT</b>		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)			
	Total (37 CFR 1.16(i))	*	Minus	**	=	X \$ =				
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X \$ =				
	<input type="checkbox"/> Application Size Fee (37 CFR 1.16(s))									
	<input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
					TOTAL ADD'L FEE					
<p>* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.</p> <p>** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".</p> <p>*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".</p> <p>The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.</p>										

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

CX-1623



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/981,290	12/28/2015	Jeroen Poeze	MASCE002C2	9573

64735	7590	05/02/2018
KNOBBE, MARTENS, OLSON & BEAR, LLP		
MASIMO CORPORATION (MASIMO)		
2040 MAIN STREET		
FOURTEENTH FLOOR		
IRVINE, CA 92614		

EXAMINER	
LIU, CHU CHUAN	

ART UNIT	PAPER NUMBER
3735	

NOTIFICATION DATE	DELIVERY MODE
05/02/2018	ELECTRONIC

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jayna.cartee@knobbe.com  
 efiling@knobbe.com

CX-1623

<b>Office Action Summary</b>	<b>Application No.</b> 14/981,290		<b>Applicant(s)</b> POEZE ET AL.	
	<b>Examiner</b> CHU CHUAN (JJ) LIU		<b>Art Unit</b> 3735	<b>AIA (First Inventor to File) Status</b> No

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --**

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 2 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1) ☒ Responsive to communication(s) filed on 02/29/2016.  
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on \_\_\_\_.

2a) ☐ This action is **FINAL**.                      2b) ☐ This action is non-final.

3) ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on \_\_\_\_; the restriction requirement and election have been incorporated into this action.

4) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims\***

5) ☒ Claim(s) 1-19 is/are pending in the application.  
5a) Of the above claim(s) \_\_\_\_ is/are withdrawn from consideration.

6) ☐ Claim(s) \_\_\_\_ is/are allowed.

7) ☐ Claim(s) \_\_\_\_ is/are rejected.

8) ☐ Claim(s) \_\_\_\_ is/are objected to.

9) ☒ Claim(s) 1-19 are subject to restriction and/or election requirement.

\* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see [http://www.uspto.gov/patents/init\\_events/pph/index.jsp](http://www.uspto.gov/patents/init_events/pph/index.jsp) or send an inquiry to [PPHfeedback@uspto.gov](mailto:PPHfeedback@uspto.gov).

**Application Papers**

10) ☐ The specification is objected to by the Examiner.

11) ☐ The drawing(s) filed on \_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a) ☐ All    b) ☐ Some\*\*    c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\*\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b)  
Paper No(s)/Mail Date \_\_\_\_.

3) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date. \_\_\_\_.

4) ☐ Other: \_\_\_\_.



Application/Control Number: 14/981,290  
Art Unit: 3735

Page 2

## **DETAILED ACTION**

### ***Election/Restrictions***

1. Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 2-4 and 12-19, drawn to a front-end interface for a noninvasive, physiological sensor comprising one or more switched capacitor/ transimpedance amplifier for converting signals to a (digital) output, classified in 600/322,336.

II. Claims 5-11, drawn to a conversion processor for a noninvasive, physiological sensor comprising a modulator converts optical signals into a digital bit-stream, classified in 600/310.

The inventions are distinct, each from the other because of the following reasons:

2. Inventions I and II are related as combination and subcombination. Inventions in this relationship are distinct if it can be shown that (1) the combination as claimed does not require the particulars of the subcombination as claimed for patentability, and (2) that the subcombination has utility by itself or in other combinations (MPEP § 806.05(c)). In the instant case, the combination as claimed does not require the particulars of the subcombination as claimed because the combination (Invention II) does not require the use of one or more switched capacitor circuits to convert signals to digital signals/ to use one or more transimpedance amplifiers to convert signals to an output signal. The subcombination has separate utility such as using switched capacitor/ transimpedance amplifier for converting signals to (digital) output.

Application/Control Number: 14/981,290  
Art Unit: 3735

Page 3

The examiner has required restriction between combination and subcombination inventions. Where applicant elects a subcombination, and claims thereto are subsequently found allowable, any claim(s) depending from or otherwise requiring all the limitations of the allowable subcombination will be examined for patentability in accordance with 37 CFR 1.104. See MPEP § 821.04(a). Applicant is advised that if any claim presented in a continuation or divisional application is anticipated by, or includes all the limitations of, a claim that is allowable in the present application, such claim may be subject to provisional statutory and/or nonstatutory double patenting rejections over the claims of the instant application.

3. Restriction for examination purposes as indicated is proper because all the inventions listed in this action are independent or distinct for the reasons given above and there would be a serious search and/or examination burden if restriction were not required because one or more of the following reasons apply:

- *the inventions have acquired a separate status in the art in view of their different classification*
- *the inventions have acquired a separate status in the art due to their recognized divergent subject matter*
- *the inventions require a different field of search (e.g., searching different classes/subclasses or electronic resources, or employing different search strategies or search queries).*

**Applicant is advised that the reply to this requirement to be complete must include (i) an election of a invention to be examined** even though the requirement may be traversed (37 CFR 1.143) **and (ii) identification of the claims encompassing the elected invention.**

Application/Control Number: 14/981,290  
Art Unit: 3735

Page 4

The election of an invention may be made with or without traverse. To reserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the restriction requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election, applicant must indicate which of these claims are readable upon the elected invention.

Should applicant traverse on the ground that the inventions are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the inventions to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103 or pre-AIA 35 U.S.C. 103(a) of the other invention.

4. This application contains claims directed to the following patentably distinct species of Group I:

Species A: Claims 2-4 (see Fig. 15L).

Species B: Claims 12-19, (see Fig. 15I).

5. The species are independent or distinct because Species A requires to use one or more switched capacitor circuits to convert signals to digital signals and Species B requires to use one or more transimpedance amplifiers to convert signals to an output

Application/Control Number: 14/981,290

Page 5

Art Unit: 3735

signal. In addition, these species are not obvious variants of each other based on the current record.

If Applicant elects the invention of Group I of the restriction, then Applicant is required under 35 U.S.C. 121 to elect a single disclosed species, or a single grouping of patentably indistinct species, for prosecution on the merits to which the claims shall be restricted if no generic claim is finally held to be allowable.

There is a search and/or examination burden for the patentably distinct species as set forth above because at least the following reason(s) apply:

- *the species or groupings of patentably indistinct species have acquired a separate status in the art in view of their different classification*
- *the species or groupings of patentably indistinct species have acquired a separate status in the art due to their recognized divergent subject matter*
- *the species or groupings of patentably indistinct species require a different field of search (e.g., searching different classes/subclasses or electronic resources, or employing different search strategies or search queries).*

**Applicant is advised that the reply to this requirement to be complete must include (i) an election of a species to be examined** even though the requirement may be traversed (37 CFR 1.143) **and (ii) identification of the claims encompassing the elected species or grouping of patentably indistinct species**, including any claims subsequently added. An argument that a claim is allowable or that all claims are generic is considered nonresponsive unless accompanied by an election.

The election may be made with or without traverse. To preserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the election of species requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time

Application/Control Number: 14/981,290

Page 6

Art Unit: 3735

of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election, applicant must indicate which of these claims are readable on the elected species or grouping of patentably indistinct species.

Should applicant traverse on the ground that the species, or groupings of patentably indistinct species from which election is required, are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing them to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the species unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103 or pre-AIA 35 U.S.C. 103(a) of the other species.

Upon the allowance of a generic claim, applicant will be entitled to consideration of claims to additional species which depend from or otherwise require all the limitations of an allowable generic claim as provided by 37 CFR 1.141.

### ***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to CHU CHUAN (JJ) LIU whose telephone number is (571)270-5507. The examiner can normally be reached on M-TH 8:30am~5:00pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an

Application/Control Number: 14/981,290  
Art Unit: 3735

Page 7

interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, JACQUELINE CHENG can be reached on (571)272-5596. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Eric Winakur/  
Primary Examiner, Art Unit 3735

/CHU CHUAN (JJ) LIU/  
Examiner, Art Unit 3735

Docket No.: MASCER.002C2

May 10, 2017

Page 1 of 1

Please Direct All Correspondence to Customer Number 64735

**RESPONSE TO INFORMATIONAL NOTICE**

First Inventor	: Jeroen Poeze
App. No.	: 14/981290
Filed	: December 28, 2015
For	: MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Art Unit	: 3735
Conf No.	: 9573

**Commissioner for Patents**  
**P.O. Box 1450**  
**Alexandria, VA 22313-1450**

Dear Sir:

The above-captioned application was filed without a Declaration and/or Substitute Statement. Enclosed in compliance with 37 CFR 1.53(f) are the following.

(X) Declaration(s) for:

Jeroen Poeze; Sean Merritt; Cristiano Dalvi; Hung Vo; Johannes Bruinsma;  
Ferdyan Lesmana; Massi Joe E. Kiani

(X) Substitute Statement in Lieu of Declaration document(s) for:

Marcelo Lamego

The Commissioner is hereby authorized to charge any additional fees which may be required, now or in the future, or credit any overpayment, to Account No. 11-1410.

/Scott Cromar/

Scott A. Cromar  
Registration No. 65,066  
Attorney of Record  
Customer No. 64735  
(949) 760-0404

25889074

CX-1623


PTO/AIA/01 (08-12)

Approved for use through 01/31/2014. OMB 0851-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN  
APPLICATION DATA SHEET (37 CFR 1.76)**

<b>Title of Invention</b>	<b>MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS</b>
<p>As the below named inventor, I hereby declare that:</p> <p>This declaration is directed to: <input type="checkbox"/> The attached application, or <input checked="" type="checkbox"/> United States application or PCT international application number <u>14/981290</u> filed on <u>December 28, 2015</u></p> <p>The above-identified application was made or authorized to be made by me.</p> <p>I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.</p> <p>I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.</p> <p style="text-align: center;"><b>WARNING:</b></p> <p>Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.</p> <p><b>LEGAL NAME OF INVENTOR</b></p> <p>Inventor: <u>Jeroen Poeze</u> Date (Optional): <u>02/27/2017</u></p> <p>Signature: <u></u></p> <p>Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.</p>	

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.



PTO/AIA/01 (06-12)

Approved for use through 01/31/2014, OMB 0851-0032

U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)**

Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
--------------------	---

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐

The attached application, or

☒United States application or PCT international application number 14/981290filed on December 28, 2015

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

**WARNING:**

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

**LEGAL NAME OF INVENTOR**Inventor: Sean MerrittDate (Optional): 2/27/2017Signature: 

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.


PTO/AIA/01 (08-12)

Approved for use through 01/31/2014, OMB 0651-0032

U.S. Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)**

<b>Title of Invention</b>	<b>MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS</b>
As the below named inventor, I hereby declare that:	
This declaration is directed to: <input type="checkbox"/> The attached application, or	
<input checked="" type="checkbox"/> United States application or PCT international application number <u>14/981290</u>	
filed on <u>December 28, 2015</u>	
The above-identified application was made or authorized to be made by me.	
I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.	
I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.	
<b>WARNING:</b>	
Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.	
<b>LEGAL NAME OF INVENTOR</b>	
Inventor: <u>Cristiano Dalvi</u>	Date (Optional): <u>2.27.17</u>
Signature: <u></u>	
Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.	

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.


PTO/AIA/01 (06-12)

Approved for use through 01/31/2014. OMB 0651-0032

U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN  
APPLICATION DATA SHEET (37 CFR 1.76)**

<b>Title of Invention</b>	<b>MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS</b>
<p>As the below named inventor, I hereby declare that:</p> <p>This declaration is directed to: <input type="checkbox"/> The attached application, or <input checked="" type="checkbox"/> United States application or PCT international application number <u>14/981290</u> filed on <u>December 28, 2015</u></p> <p>The above-identified application was made or authorized to be made by me.</p> <p>I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.</p> <p>I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.</p> <p style="text-align: center;"><b>WARNING:</b></p> <p>Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.</p> <p><b>LEGAL NAME OF INVENTOR</b></p> <p>Inventor: <u>Hung Vo</u> Date (Optional): <u>2/27/17</u></p> <p>Signature: <u></u></p> <p>Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.</p>	

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/01 (06-12)

Approved for use through 01/31/2014. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

<b>Title of Invention</b>	<b>MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS</b>
-------------------------------	--

As the below named inventor, I hereby declare that:

This declaration is directed to: ☐ The attached application, or ☒ United States application or PCT international application number 14/981290 filed on December 28, 2015.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.


I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

**WARNING:**

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

**LEGAL NAME OF INVENTOR**

Inventor: Johannes Bruinsma Date (Optional): May-8-2017

Signature: 

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

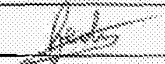
PTO/AIA/01 (06-12)

Approved for use through 01/31/2014. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)**

<b>Title of Invention</b>	<b>MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS</b>
<p>As the below named inventor, I hereby declare that:</p> <p>This declaration is directed to: <input type="checkbox"/> The attached application, or <input checked="" type="checkbox"/> United States application or PCT international application number <u>14/981290</u> filed on <u>December 28, 2015</u></p> <p>The above-identified application was made or authorized to be made by me.</p> <p>I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.</p> <p>I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.</p> <p style="text-align: center;"><b>WARNING:</b></p> <p>Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.</p> <p><b>LEGAL NAME OF INVENTOR</b></p> <p>Inventor: <u>Ferdyan Lesmana</u> Date (Optional): <u>2/27/2017</u></p> <p>Signature: <u></u></p> <p>Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.</p>	

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2



PTO/AIA/01 (08-12)

Approved for use through 01/31/2014. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)**

<b>Title of Invention</b>	<b>MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS</b>
<p>As the below named inventor, I hereby declare that:</p> <p>This declaration is directed to: <input type="checkbox"/> The attached application, or</p> <p><input checked="" type="checkbox"/> United States application or PCT international application number <u>14/981290</u> filed on <u>December 28, 2015</u></p> <p>The above-identified application was made or authorized to be made by me.</p> <p>I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.</p> <p>I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.</p> <p style="text-align: center;"><b>WARNING:</b></p> <p>Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.</p>	
<b>LEGAL NAME OF INVENTOR</b>	
Inventor: <u>Massi Joe E. Kiani</u>	Date (Optional): <u>3-8-17</u>
Signature: <u>[Signature]</u>	
<p>Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.</p>	

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

CX-1623

Doc code: Oath

Document Description: Oath or declaration filed

PTO/AIA/02 (07-13)

Approved for use through 01/31/2014. OMB 0651-0032

U.S. Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY  
OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)**

<b>Title of Invention</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
This statement is directed to:			
<input type="checkbox"/> The attached application,			
OR			
<input checked="" type="checkbox"/> United States application or PCT international application number <u>14/981290</u> filed on <u>December 28, 2015</u>			
<b>LEGAL NAME of inventor to whom this substitute statement applies:</b>			
(E.g., Given Name (first and middle (if any)) and Family Name or Surname)			
Marcelo Lamego			
Residence (except for a deceased or legally incapacitated inventor):			
City	State	Country	
Cupertino	CA	US	
Mailing Address (except for a deceased or legally incapacitated inventor):			
10292 Orange Avenue			
City	State	Zip	Country
Cupertino	CA	95014	US
I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.			
The above-identified application was made or authorized to be made by me.			
I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.			
Relationship to the inventor to whom this substitute statement applies:			
<input type="checkbox"/> Legal Representative (for deceased or legally incapacitated inventor only),			
<input checked="" type="checkbox"/> Assignee,			
<input type="checkbox"/> Person to whom the inventor is under an obligation to assign,			
<input type="checkbox"/> Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or			
<input type="checkbox"/> Joint Inventor.			

[Page 1 of 2]

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

CX-1623

PTO/SB/AIA02 (07-13)

Approved for use through 01/31/2014. OMB 0851-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**SUBSTITUTE STATEMENT**

Circumstances permitting execution of this substitute statement:

- ☐ Inventor is deceased,  
☐ Inventor is under legal incapacity,  
☐ Inventor cannot be found or reached after diligent effort, or  
☒ Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- ☒ An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR


- ☐ An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

**WARNING:**

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

**PERSON EXECUTING THIS SUBSTITUTE STATEMENT:**Name: **Thomas McClenahan**

Date (Optional):

Signature: **APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:**

If the applicant is a juristic entity, list the applicant name and the title of the signer:

**Masimo Corporation**

Applicant Name:

Title of Person Executing  
This Substitute Statement: **Executive Vice President and General Counsel**

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

**Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):**City **Irvine** State **CA** Country **US**

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

**52 Discovery**City **Irvine** State **CA** Zip **92618** Country **US**

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

[Page 2 of 2]



CX-1623

Electronic Acknowledgement Receipt	
<b>EFS ID:</b>	29168246
<b>Application Number:</b>	14981290
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9573
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	64735
<b>Filer:</b>	Scott Cromar/Heide Young
<b>Filer Authorized By:</b>	Scott Cromar
<b>Attorney Docket Number:</b>	MASCER.002C2
<b>Receipt Date:</b>	10-MAY-2017
<b>Filing Date:</b>	28-DEC-2015
<b>Time Stamp:</b>	12:57:05
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	no
------------------------	----

**File Listing:**

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	Transmittal_MASCER002C2.pdf	17684 c4ece33ab2572cfe97082b3c904ad55e2f111cb3	no	1

**Warnings:**

Page 432 of 643

**Appx59792**

CX-1623

<b>Information:</b>					
2	Oath or Declaration filed	Declarations_MASCER002C2.PDF	1060612  d63c00d2ef5aec73162eb1d74efdc743faa4339	no	9
<b>Warnings:</b>					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
<b>Information:</b>					
<b>Total Files Size (in bytes):</b>			1078296		
<p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>  If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>  If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>  If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p>					



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/981,290	12/28/2015	Jeroen Poeze	MASCER.002C2

**CONFIRMATION NO. 9573**

64735

KNOBBE, MARTENS, OLSON & BEAR, LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

**PUBLICATION NOTICE**

\*OC000000083701453\*

**Title:**MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

**Publication No.**US-2016-0166183-A1

**Publication Date:**06/16/2016

**NOTICE OF PUBLICATION OF APPLICATION**

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at [www.uspto.gov](http://www.uspto.gov). The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at [www.uspto.gov](http://www.uspto.gov) using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <http://pair.uspto.gov/>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO.	TOT CLAIMS	IND CLAIMS
14/981,290	12/28/2015	2688	1740	MASCER.002C2	18	3

CONFIRMATION NO. 9573

## UPDATED FILING RECEIPT



000000081288622

64735  
 KNOBBE, MARTENS, OLSON & BEAR, LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

Date Mailed: 03/09/2016

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

## Inventor(s)

Jeroen Poeze, Rancho Santa Margarita, CA;  
 Marcelo Lamego, Cupertino, CA;  
 Sean Merritt, Lake Forest, CA;  
 Cristiano Dalvi, Lake Forest, CA;  
 Hung Vo, Fountain Valley, CA;  
 Johannes Bruinsma, Opeinde, NETHERLANDS;  
 Ferdyan Lesmana, Irvine, CA;  
 Massi Joe E. Kiani, Laguna Niguel, CA;

## Applicant(s)

MASIMO CORPORATION, Irvine, CA;

**Power of Attorney:** The patent practitioners associated with Customer Number 64735

**Domestic Priority data as claimed by applicant**

This application is a CON of 12/829,352 07/01/2010 PAT 9277880  
 which is a CON of 12/534,827 08/03/2009 ABN  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and said 12/829,352 07/01/2010  
 is a CIP of 12/497,528 07/02/2009 PAT 8577431  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008

page 1 of 4

and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008 PAT D621516  
 and is a CIP of 29/323,408 08/25/2008 PAT D606659  
 and said 12/829,352 07/01/2010  
 is a CIP of 12/497,523 07/02/2009 PAT 8437825  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008 PAT D621516  
 and is a CIP of 29/323,408 08/25/2008 PAT D606659

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 01/14/2016

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/981,290**

**Projected Publication Date:** 06/16/2016

**Non-Publication Request:** No

**Early Publication Request:** No

**Title**

MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

**Preliminary Class**

369

**Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:** No

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international

page 2 of 4

application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

## **LICENSE FOR FOREIGN FILING UNDER**

### **Title 35, United States Code, Section 184**

### **Title 37, Code of Federal Regulations, 5.11 & 5.15**

#### **GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national

security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

**NOT GRANTED**

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

---

**SelectUSA**

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/981,290	12/28/2015	Jeroen Poeze	MASCER.002C2

**CONFIRMATION NO. 9573**

64735

KNOBBE, MARTENS, OLSON & BEAR, LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

**INFORMAL NOTICE**

Date Mailed: 03/09/2016

**INFORMATIONAL NOTICE TO APPLICANT**

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):  
 Jeroen Poeze  
 Marcelo Lamego  
 Sean Merritt  
 Cristiano Dalvi  
 Hung Vo  
 Johannes Bruinsma  
 Ferdyan Lesmana  
 Massi Joe E. Kiani

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/dgela/



<b>PATENT APPLICATION FEE DETERMINATION RECORD</b>						Application or Docket Number 14/981,290				
Substitute for Form PTO-875										
<b>APPLICATION AS FILED - PART I</b>										
(Column 1)		(Column 2)		SMALL ENTITY		OR OTHER THAN SMALL ENTITY				
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)			
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280			
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A	600			
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720			
TOTAL CLAIMS (37 CFR 1.16(i))	18	minus 20 = *			OR	x 80 =	0.00			
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3	minus 3 = *				x 420 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1600			
<b>APPLICATION AS AMENDED - PART II</b>										
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OR OTHER THAN SMALL ENTITY		
AMENDMENT A		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)
	Total (37 CFR 1.16(i))	*	Minus	**	=	x	=	OR	x	=
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=	OR	x	=
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	
AMENDMENT B		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)
	Total (37 CFR 1.16(i))	*	Minus	**	=	x	=	OR	x	=
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=	OR	x	=
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	
<p style="font-size: x-small;">* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.</p> <p style="font-size: x-small;">** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".</p> <p style="font-size: x-small;">*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".</p> <p style="font-size: x-small;">The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.</p>										

MASCER.002C2

PATENT

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Inventor	:	Jeroen Poeze
App. No.	:	14/981290
Filed	:	December 28, 2015
For	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner	:	Unknown
Art Unit	:	2688
Conf. No.	:	9573

**PRELIMINARY AMENDMENT**

**Mail Stop Amendment**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

Prior to examination, please consider the following:

**Amendments to the Claims** are reflected in the listing of claims which begins on page 2 of this paper.

**Remarks** begin on page 5 of this paper.

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

### AMENDMENTS TO THE CLAIMS

1. (Canceled)
2. (New) A front-end interface for a noninvasive, physiological sensor, said front-end interface comprising:
  - one or more inputs configured to receive signals from respective one or more detectors in the sensor;
  - one or more switched capacitor circuits configured to convert the one or more signals from the one or more detectors into a digital output signal having a stream for each of the one or more detectors; and
  - an output configured to provide the digital output signal.
3. (New) The front-end interface of Claim 2, wherein the front-end interface is integrated with the sensor.
4. (New) The front-end interface of Claim 2, wherein the one or more detectors include at least two detectors, wherein the one or more switched capacitor circuits include at least two switched capacitor circuits, and wherein the at least two switched capacitor circuits are configured to combine the streams of a set of the two or more detectors into a single stream.
5. (New) A conversion processor for a physiological, noninvasive sensor, said conversion processor comprising:
  - a multi-stream input configured to receive signals from at least one detector in the sensor, wherein the signals are responsive to optical radiation from a tissue site;
  - a modulator that converts the multi-stream input into a digital bit-stream; and
  - a signal processor that produces an output signal from the digital bit-stream.
6. (New) The conversion processor of Claim 5, wherein at least one of the a first detector of the at least one detector in the sensor comprises a set of photodiodes coupled together into a group.
7. (New) The conversion processor of Claim 6, wherein the first detector in the sensor comprises a set of two photodiodes coupled together.
8. (New) The conversion processor of Claim 7, wherein the first detector in the sensor comprises a set of three photodiodes coupled together.

**Application No.: 14/981290**  
**Filing Date: December 28, 2015**

9. (New) The conversion processor of Claim 7, wherein the first detector in the sensor comprises a set of four photodiodes coupled together.

10. (New) The conversion processor of Claim 7, wherein the first detector in the sensor comprises a set of nine photodiodes coupled together.

11. (New) The conversion processor of Claim 6, wherein the first detector in the sensor comprises a set photodiodes coupled together to provide a detection area of approximately 1 mm<sup>2</sup>.

12. (New) A front-end interface for a noninvasive, physiological sensor, said front-end interface comprising:

one or more inputs configured to receive signals from respective one or more detectors in the sensor;

one or more transimpedance amplifiers for each respective detector and configured to convert the signals from the respective one or more detectors into an output signal having a stream for each of the one or more detectors; and

an output configured to provide the output signal.

13. (New) The front-end interface of Claim 12, further comprising an averager, coupled to the one or more transimpedance amplifiers and the output, configured to average digital output signals from the respective one or more transimpedance amplifiers into the single output signal.

14. (New) The front-end interface of Claim 12, wherein at least a first of the one or more detectors in the sensor comprises a set of photodiodes coupled together into a group.

15. (New) The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set of two photodiodes coupled together.

16. (New) The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set of three photodiodes coupled together.

17. (New) The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set of four photodiodes coupled together.

18. (New) The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set of nine photodiodes coupled together.

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

19. (New) The front-end interface of Claim 13, wherein the first detector in the sensor comprises a set photodiodes coupled together to provide a detection area of approximately 1 mm<sup>2</sup>.

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

### REMARKS

By way of summary, Claim 1 was pending in this application. In the present amendment, the Applicant has canceled Claim 1 without prejudice or disclaimer of subject matter, and added new Claims 2-19. Applicant reserves the right to pursue previously pending claims in this or another application. Accordingly, Claims 2-19 remain pending for consideration.

#### No Disclaimers or Disavowals

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

#### Co-Pending Applications of Assignee

Applicant wishes to draw the Examiner's attention to the following co-pending applications of the present application's assignee.

Docket No.	Serial No.	Title	Filed
MASCER.006C1	14/069974	NOISE SHIELDING FOR A NONINVAISE DEVICE	11-01-2013
MASCER.007C1	13/888266	CONTOURED PROTRUSION FOR IMPROVING SPECTROSCOPIC MEASUREMENT OF BLOOD CONSTITUENTS	05-06-2013

**Application No.:** 14/981290  
**Filing Date:** December 28, 2015

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: February 29, 2016

By: /Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Attorney of Record  
Customer No. 64735  
(949) 760-0404

22716736

Electronic Patent Application Fee Transmittal				
<b>Application Number:</b>	14981290			
<b>Filing Date:</b>	28-Dec-2015			
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS			
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze			
<b>Filer:</b>	Scott Cromar/Daniella Kellogg			
<b>Attorney Docket Number:</b>	MASCER.002C2			
Filed as Large Entity				
<b>Filing Fees for Utility under 35 USC 111(a)</b>				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
<b>Basic Filing:</b>				
Utility application filing	1011	1	280	280
Utility Search Fee	1111	1	600	600
Utility Examination Fee	1311	1	720	720
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
Late Filing Fee for Oath or Declaration	1051	1	140	140
<b>Petition:</b>				



CX-1623

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1740

CX-1623

<b>Electronic Acknowledgement Receipt</b>	
<b>EFS ID:</b>	25054312
<b>Application Number:</b>	14981290
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9573
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	64735
<b>Filer:</b>	Scott Cromar/ThuyQuyen Nguyen
<b>Filer Authorized By:</b>	Scott Cromar
<b>Attorney Docket Number:</b>	MASCER.002C2
<b>Receipt Date:</b>	29-FEB-2016
<b>Filing Date:</b>	28-DEC-2015
<b>Time Stamp:</b>	17:52:57
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	\$1740
RAM confirmation Number	6050
Deposit Account	111410
Authorized User	KNOBBE MARTENS OLSON AND BEAR
<p>The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:</p> <p>Charge any Additional Fees required under 37 CFR 1.16 (National application filing, search, and examination fees)</p> <p>Charge any Additional Fees required under 37 CFR 1.17 (Patent application and reexamination processing fees)</p>	

Page 449 of 643

CX-1623

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	MPARTS_MASCER-002C2.pdf	17810	no	1
			9c24c2d4e21e160881b34f6632e1464d6819d565		
Warnings:					
Information:					
2		PAMD_MASCER-002C2.pdf	36402	yes	6
			2fa5c1102a4a62629ed25fb2c197a405366c84ad		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Preliminary Amendment		1	1	
	Claims		2	4	
	Applicant Arguments/Remarks Made in an Amendment		5	6	
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	37216	no	2
			c881b8dc6db81475246dc3c37192dac1b87601d5		
Warnings:					
Information:					
Total Files Size (in bytes):			91428		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Docket No.: MASCER.002C2

February 29, 2016

Page 1 of 1

Please Direct All Correspondence to Customer Number 64735

---

**RESPONSE TO FORMALITIES NOTICE**

Inventor	:	Jeroen Poeze
App. No.	:	14/981290
Filed	:	December 28, 2015
For	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Art Unit	:	2688
Conf. No.	:	9573

**Mail Stop Missing Parts  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450**

Dear Sir:

The above-captioned application was filed lacking at least one item that would advance application to examination. Enclosed in compliance with 37 CFR 1.53(f) are the following.

- (X) A Preliminary Amendment.
- (X) Fees will be paid via EFS Web. Any extension of time will be requested by payment of the appropriate extension fee.

The Commissioner is hereby authorized to charge any additional fees which may be required, now or in the future, or credit any overpayment, to Account No. 11-1410.

/Scott Cromar/  
Scott A. Cromar  
Registration No. 65,066  
Attorney of Record  
Customer No. 64735  
(949) 760-0404

22797438



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/981,290	12/28/2015	Jeroen Poeze	MASCER.002C2

CONFIRMATION NO. 9573

## FORMALITIES LETTER

64735

KNOBBE, MARTENS, OLSON & BEAR, LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614



\*OC000000079948094\*

Date Mailed: 01/19/2016

## NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

*Filing Date Granted***Items Required To Avoid Abandonment:**

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
- The application search fee must be submitted.
- The application examination fee must be submitted.
- Surcharge as set forth in 37 CFR 1.16(f) must be submitted.

The surcharge is due for any one of:

- late submission of the basic filing fee, search fee, or examination fee,
- late submission of inventor's oath or declaration,
- filing an application that does not contain at least one claim on filing, or
- submission of an application filed by reference to a previously filed application.

**SUMMARY OF FEES DUE:**

The fee(s) required within **TWO MONTHS** from the date of this Notice to avoid abandonment is/are itemized below. No entity status discount is in effect. If applicant is qualified for small entity status, a written assertion of small entity status must be submitted to establish small entity status. (See 37 CFR 1.27). If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- \$ 280 basic filing fee.
- \$ 140 surcharge.
- \$ 600 search fee.
- \$ 720 examination fee.
- \$( 0) previous unapplied payment amount.
- \$ 1740 TOTAL FEE BALANCE DUE.

**Items Required To Avoid Processing Delays:**

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):

Jeroen Poeze  
Marcelo Lamego  
Sean Merritt  
Cristiano Dalvi  
Hung Vo  
Johannes Bruinsma  
Ferdyan Lesmana  
Massi Joe E. Kiani

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts  
Commissioner for Patents  
P.O. Box 1450  
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice".  
<https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html>

For more information about EFS-Web please call the USPTO Electronic Business Center at 1-866-217-9197 or visit our website at <http://www.uspto.gov/ebc>.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/sstephanos/

---



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
14/981,290	12/28/2015	2688	0.00	MASER.002C2	1	1

CONFIRMATION NO. 9573

## FILING RECEIPT



CC00000079948093

64735  
 KNOBBE, MARTENS, OLSON & BEAR, LLP  
 2040 MAIN STREET  
 FOURTEENTH FLOOR  
 IRVINE, CA 92614

Date Mailed: 01/19/2016

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

## Inventor(s)

Jeroen Poeze, Rancho Santa Margarita, CA;  
 Marcelo Lamego, Cupertino, CA;  
 Sean Merritt, Lake Forest, CA;  
 Cristiano Dalvi, Lake Forest, CA;  
 Hung Vo, Fountain Valley, CA;  
 Johannes Bruinsma, Opeinde, NETHERLANDS;  
 Ferdyan Lesmana, Irvine, CA;  
 Massi Joe E. Kiani, Laguna Niguel, CA;

## Applicant(s)

MASIMO CORPORATION, Irvine, CA;

**Power of Attorney:** The patent practitioners associated with Customer Number 64735

**Domestic Priority data as claimed by applicant**

This application is a CON of 12/829,352 07/01/2010  
 which is a CON of 12/534,827 08/03/2009 ABN  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and said 12/829,352 07/01/2010  
 is a CIP of 12/497,528 07/02/2009 PAT 8577431  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008

page 1 of 4



and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008 PAT D621516  
 and is a CIP of 29/323,408 08/25/2008 PAT D606659  
 and said 12/829,352 07/01/2010  
 is a CIP of 12/497,523 07/02/2009 PAT 8437825  
 which claims benefit of 61/086,060 08/04/2008  
 and claims benefit of 61/086,108 08/04/2008  
 and claims benefit of 61/086,063 08/04/2008  
 and claims benefit of 61/086,057 08/04/2008  
 and claims benefit of 61/078,228 07/03/2008  
 and claims benefit of 61/078,207 07/03/2008  
 and claims benefit of 61/091,732 08/25/2008  
 and is a CIP of 29/323,409 08/25/2008 PAT D621516  
 and is a CIP of 29/323,408 08/25/2008 PAT D606659

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 01/14/2016

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/981,290**

**Projected Publication Date:** To Be Determined - pending completion of Missing Parts

**Non-Publication Request:** No

**Early Publication Request:** No

**Title**

MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS

**Preliminary Class**

369

**Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:** No

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international

page 2 of 4

application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

## **LICENSE FOR FOREIGN FILING UNDER**

### **Title 35, United States Code, Section 184**

### **Title 37, Code of Federal Regulations, 5.11 & 5.15**

#### **GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national

security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

**NOT GRANTED**

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

---

***SelectUSA***

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

CX-1623

<b>PATENT APPLICATION FEE DETERMINATION RECORD</b>						Application or Docket Number 14/981,290				
Substitute for Form PTO-875										
<b>APPLICATION AS FILED - PART I</b>										
(Column 1)		(Column 2)		SMALL ENTITY		OR OTHER THAN SMALL ENTITY				
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)			
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280			
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A	600			
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720			
TOTAL CLAIMS (37 CFR 1.16(i))	1	minus 20 = *			OR	x 80 =	0.00			
INDEPENDENT CLAIMS (37 CFR 1.16(h))	1	minus 3 = *				x 420 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1600			
<b>APPLICATION AS AMENDED - PART II</b>										
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OR OTHER THAN SMALL ENTITY		
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)		
	Total (37 CFR 1.16(i))	*	Minus	**	=	x	=	OR	x	=
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=	OR	x	=
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE		
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)		
	Total (37 CFR 1.16(i))	*	Minus	**	=	x	=	OR	x	=
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=	OR	x	=
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE		
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3. ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.										

Doc Code: PA..

Document Description: Power of Attorney

CX-1623

PTO/AIA/82A (07-13)

Approved for use through 11/30/2014. OMB 0651-0051

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

## TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA/82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	Unknown
Filing Date	Herewith
First Named Inventor	Jeroen Poeze
Title	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Art Unit	Unknown
Examiner Name	Unknown
Attorney Docket Number	MASCER.002C2

### SIGNATURE of Applicant or Patent Practitioner

Signature	/Scott Cromar/	Date (Optional)	
Name	Scott Cromar	Registration Number	65066
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

**NOTE:** This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.



\*Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

CX-1623

Doc Code: PA..

Document Description: Power of Attorney

PTO/AIA/82B(07-12)

Approved for use through 11/30/2014. OMB 0651-0035

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**POWER OF ATTORNEY BY APPLICANT**

I hereby revoke all previous powers of attorney given in the application identified in the attached transmittal letter.

- ☒ I hereby appoint Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A or equivalent):

64735

OR

- ☐ I hereby appoint Practitioner(s) named below as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A or equivalent):

Name	Registration Number	Name	Registration Number

Please recognize or change the correspondence address for the application identified in the attached transmittal letter to:

- ☒ The address associated with the above-mentioned Customer Number.

OR

- ☐ The address associated with Customer Number:

OR

☐ Firm or  
Individual Name

Address

City

State

Zip

Country

Telephone

Email

I am the Applicant:

- ☐ Inventor or Joint Inventor
- ☐ Legal Representative of a Deceased or Legally Incapacitated Inventor
- ☒ Assignee or Person to Whom the Inventor is Under an Obligation to Assign
- ☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document)

**SIGNATURE of Applicant for Patent**

Signature		Date	7/12/13
Name	Thomas McClenahan	Telephone	(949) 297-7000
Title and Company	Executive Vice President and General Counsel, Masimo Corporation		

**NOTE:** Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms for more than one signature, see below \*

- ☒ \*Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Docket No.: MASCER.002C2

Customer No. 64735

**INFORMATION DISCLOSURE STATEMENT**

Inventor	:	Jeroen Poeze
App. No.	:	Unknown
Filed	:	Herewith
For	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner	:	Unknown
Art Unit	:	Unknown
Conf. No.	:	Unknown

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

**References and Listing**

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. Listed references are of record in U.S. patent application No. 12/829352, filed July 10, 2010, which is the parent of this Continuation application, and is relied upon for an earlier filing date under 35 USC 120. Copies of the references are not submitted pursuant to 37 CFR 1.98(d).

Pursuant to 37 CFR 1.97(g) and (h), Applicants make no representation that the information is considered to be material to patentability. Additionally, inclusion on this list is not an admission that any of the cited documents are prior art in this application. Further, Applicants make no representation regarding the completeness of this list, or that better art does not exist.

**Co-Pending Applications of Assignee**

Applicant wishes to draw the Examiner's attention to the following co-pending applications of the present application's assignee.

Docket No.	Serial No.	Title	Filed
MASCER.006C1	14/069974	NOISE SHIELDING FOR A NONINVAISE DEVICE	11-01-2013

**Application No.:** Unknown  
**Filing Date:** Herewith

MASCER.007C1	13/888266	CONTOURED PROTRUSION FOR IMPROVING SPECTROSCOPIC MEASUREMENT OF BLOOD CONSTITUENTS	05-06-2013
--------------	-----------	---	------------

Applicant directs the Examiner to these applications to consider whether the subject matter claimed, now or as may be amended in the future, as well as the associated prosecution history, now or in the future, may be relevant to the patentability of the present application (e.g., for reasons of double patenting). Applicant believes that the Examiner has access to the applications and associated file histories through the Patent Office (e.g., the IFW system). Accordingly, Applicant has not provided copies of these applications or their associated file histories. Applicant would be happy to provide copies of any of these applications or their associated file histories, now or in the future, should the Examiner so request.

#### **No Disclaimers**

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

#### **Timing of Disclosure**

This Information Disclosure Statement is being filed within three months of the filing date and no fee is believed to be required.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: December 28, 2015

By: /Scott Cromar/\_\_\_\_\_  
 Scott A. Cromar  
 Registration No. 65,066  
 Attorney of Record  
 Customer No. 64735  
 (949) 760-0404

22338398



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 1 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	3,910,701	10/07/1975	Henderson et al.	
	2	4,114,604	09/19/1978	Shaw et al.	
	3	4,258,719	03/31/1981	Lewyn	
	4	4,267,844	05/19/1981	Yamanishi	
	5	4,444,471	04/24/1984	Ford et al.	
	6	4,655,225	04/07/1987	Dahne et al.	
	7	4,684,245	08/04/1987	Goldring	
	8	4,755,676	07/05/1988	Gaalema et al.	
	9	4,781,195	11/01/1988	Martin	
	10	4,805,623	02/21/1989	Jöbsis	
	11	4,880,304	11/14/1989	Jaeb et al.	
	12	4,960,128	10/02/1990	Gordon et al.	
	13	4,964,408	10/23/1990	Hink et al.	
	14	5,028,787	07/02/1991	Rosenthal, et al.	
	15	5,035,243	07/30/1991	Muz, Edwin	
	16	5,041,187	08/20/1991	Hink et al.	
	17	5,043,820	08/27/1991	Wyles et al.	
	18	5,069,213	12/03/1991	Polczynski	
	19	5,069,214	12/03/1991	Samaras et al.	
	20	5,077,476	12/31/1991	Rosenthal	
	21	5,086,229	02/04/1992	Rosenthal et al.	
	22	5,122,925	06/16/1992	Inpyn	
	23	5,131,391	07/21/1992	Sakai et al.	
	24	5,137,023	08/11/1992	Mendelson, et al.	
	25	5,159,929	11/03/1992	McMillen et al.	
	26	5,163,438	11/17/1992	Gordon et al.	
	27	5,222,295	06/29/1993	Dpriss Jr.	
	28	5,222,495	06/29/1993	Clarke et al.	
	29	5,222,496	06/29/1993	Clarke et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 2 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	5,249,576	10/05/1993	Goldberger et al.	
	31	5,278,627	01/11/1994	Aoyagi et al.	
	32	5,297,548	03/29/1994	Pologe, Jonas A.	
	33	5,319,355	06/07/1994	Russek	
	34	5,337,744	08/16/1994	Branigan	
	35	5,337,745	08/16/1994	Benaron	
	36	5,341,805	08/30/1994	Stavridi, et al.	
	37	5,362,966	11/08/1994	Rosenthal et al.	
	38	5,377,676	01/03/1995	Vari, et al.	
	39	5,427,093	06/27/1995	Ogawa et al.	
	40	5,431,170	07/11/1995	Mathews	
	41	5,437,275	08/01/1995	Amundsen et al.	
	42	5,441,054	08/15/1995	Tsuchiya	
	43	5,452,717	09/26/1995	Branigan et al.	
	44	5,456,252	10/10/1995	Vari, et al.	
	45	5,479,934	01/02/1996	Imran	
	46	5,482,034	01/09/1996	Lewis et al.	
	47	5,482,036	01/09/1996	Diab et al.	
	48	5,490,505	02/13/1996	Diab et al.	
	49	5,494,043	02/27/1996	O'Sullivan et al.	
	50	5,511,546	04/30/1996	Hon	
	51	5,533,511	07/09/1996	Kaspari et al.	
	52	5,534,851	07/09/1996	Russek	
	53	5,551,422	09/03/1996	Simonsen et al.	
	54	5,553,615	09/10/1996	Carim et al.	
	55	5,553,616	09/09/1996	Ham et al.	
	56	5,561,275	10/01/1996	Savage, et al.	
	57	5,562,002	10/08/1996	Lalin	
	58	5,590,649	01/07/1997	Caro et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 3 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	5,602,924	02/11/1997	Durand et al.	
	60	5,625,458	04/29/1997	Alfano et al.	
	61	5,632,272	05/27/1997	Diab et al.	
	62	5,638,816	06/17/1997	Kiani-Azarbayjany et al.	
	63	5,638,818	06/17/1997	Diab et al.	
	64	5,645,440	07/08/1997	Tobler et al.	
	65	5,676,143	10/14/1997	Simonsen, et al.	
	66	5,685,299	11/11/1997	Diab et al.	
	67	5,743,262	04/28/1998	Lepper, Jr. et al.	
	68	5,750,927	05/12/1998	Baltazar, Osni	
	69	5,752,914	05/19/1998	Delonzor et al.	
	70	5,758,644	06/02/1998	Diab et al.	
	71	5,760,910	06/02/1998	Lepper, Jr. et al.	
	72	5,766,131	06/16/1998	Kondo et al.	
	73	5,769,785	06/23/1998	Diab et al.	
	74	5,782,757	07/21/1998	Diab et al.	
	75	5,785,659	07/28/1998	Caro et al.	
	76	5,791,347	08/11/1998	Flaherty et al.	
	77	5,792,052	08/11/1998	Isaacson et al.	
	78	5,810,734	09/22/1998	Caro et al.	
	79	5,823,950	10/20/1998	Diab et al.	
	80	5,826,885	10/27/1998	Helgeland	
	81	5,830,131	11/03/1998	Caro et al.	
	82	5,833,618	11/10/1998	Caro et al.	
	83	5,851,178	12/22/1998	Aronow	
	84	5,860,919	01/19/1999	Kiani-Azarbayjany et al.	
	85	5,890,929	04/06/1999	Mills et al.	
	86	5,902,235	05/11/1999	Lewis et al.	
	87	5,903,357	05/11/1999	Colak	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 4 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	5,904,654	05/18/1999	Wohltmann et al.	
	89	5,919,134	07/06/1999	Diab	
	90	5,934,925	08/10/1999	Tobler et al.	
	91	5,940,182	08/17/1999	Lepper, Jr. et al.	
	92	5,957,840	09/28/1999	Terasawa et al.	
	93	5,995,855	11/30/1999	Kiani et al.	
	94	5,997,343	12/07/1999	Mills et al.	
	95	6,002,952	12/14/1999	Diab et al.	
	96	6,011,986	01/04/2000	Diab et al.	
	97	6,027,452	02/22/2000	Flaherty et al.	
	98	6,036,642	03/14/2000	Diab et al.	
	99	6,045,509	04/04/2000	Caro et al.	
	100	6,049,727	04/11/2000	Crothall, Katherine D.	
	101	6,067,462	05/23/2000	Diab et al.	
	102	6,081,735	06/27/2000	Diab et al.	
	103	6,088,607	07/11/2000	Diab et al.	
	104	6,110,522	08/29/2000	Lepper, Jr. et al.	
	105	6,124,597	09/26/2000	Shehada	
	106	6,128,521	10/03/2000	Marro et al.	
	107	6,129,675	10/10/2000	Jay	
	108	6,144,866	11/07/2000	Miesel et al.	
	109	6,144,868	11/07/2000	Parker	
	110	6,151,516	11/21/2000	Kiani-Azarbayjany et al.	
	111	6,152,754	11/28/2000	Gerhardt et al.	
	112	6,157,850	12/05/2000	Diab et al.	
	113	6,165,005	12/26/2000	Mills et al.	
	114	6,172,743	01/09/2001	Kley, et al.	
	115	6,181,958	01/30/2001	Steuer et al.	
	116	6,184,521	02/06/2001	Coffin, IV et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 5 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	117	6,206,830	03/27/2001	Diab et al.	
	118	6,223,063	04/24/2001	Chaiken et al.	
	119	6,229,856	05/08/2001	Diab et al.	
	120	6,232,609	05/15/2001	Snyder, et al.	
	121	6,236,872	05/22/2001	Diab et al.	
	122	6,241,683	06/05/2001	Macklem, et al.	
	123	6,253,097	06/26/2001	Aronow et al.	
	124	6,256,523	07/03/2001	Diab et al.	
	125	6,263,222	07/17/2001	Diab et al.	
	126	6,278,522	08/21/2001	Lepper, Jr. et al.	
	127	6,278,889	08/21/2001	Robinson	
	128	6,280,213	08/28/2001	Tobler et al.	
	129	6,285,896	09/04/2001	Tobler et al.	
	130	6,301,493	10/09/2001	Marro et al.	
	131	6,317,627	11/13/2001	Ennen et al.	
	132	6,321,100	11/20/2001	Parker	
	133	6,325,761	12/04/2001	Jay	
	134	6,334,065	12/25/2001	Al-Ali et al.	
	135	6,343,223	01/29/2002	Chin et al.	
	136	6,343,224	01/29/2002	Parker	
	137	6,345,194	02/05/2002	Robert Nelson, et al.	
	138	6,349,228	02/19/2002	Kiani et al.	
	139	6,353,750	03/05/2002	Kimura et al.	
	140	6,360,113	03/09/2002	Dettling, Allen	
	141	6,360,114	03/09/2002	Diab et al.	
	142	6,360,115	03/19/2002	Roger Greenwald, et al.	
	143	6,368,283	04/09/2002	Xu, et al.	
	144	6,371,921	04/16/2002	Caro et al.	
	145	6,377,829	04/23/2002	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 6 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	146	6,388,240	05/14/2002	Schulz et al.	
	147	6,397,091	05/28/2002	Diab et al.	
	148	6,430,437	08/06/2002	Marro	
	149	6,430,525	08/06/2002	Weber et al.	
	150	6,463,311	10/08/2002	Diab	
	151	6,470,199	10/22/2002	Kopotic et al.	
	152	6,501,975	12/31/2002	Diab et al.	
	153	6,505,059	01/07/2003	Kollias, et al.	
	154	6,515,273	02/04/2003	Al-Ali	
	155	6,519,487	02/11/2003	Parker	
	156	6,522,521	02/18/2003	Abdul-Hafiz et al.	
	157	6,525,386	02/25/2003	Mills et al.	
	158	6,526,300	02/25/2003	Kiani et al.	
	159	6,541,756	04/01/2003	Schulz et al.	
	160	6,542,764	04/01/2003	Al-Ali et al.	
	161	6,580,086	06/17/2003	Schulz et al.	
	162	6,584,336	06/24/2003	Ali et al.	
	163	6,595,316	07/22/2003	Cybulski et al.	
	164	6,597,932	07/22/2003	Tian et al.	
	165	6,597,933	07/22/2003	Kiani et al.	
	166	6,606,509	08/12/2003	Schmitt, Joseph M.	
	167	6,606,511	08/12/2003	Ali et al.	
	168	6,632,181	10/14/2003	Flaherty et al.	
	169	6,636,759	10/21/2003	Robinson	
	170	6,639,668	10/28/2003	Trepagnier, Pierre	
	171	6,639,867	10/28/2003	Shim	
	172	37,922	03/17/1983	Shim	
	173	6,640,116	10/28/2003	Diab	
	174	6,643,530	11/04/2003	Diab et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 7 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	175	6,650,917	11/18/2003	Diab et al.	
	176	6,654,624	11/25/2003	Diab et al.	
	177	6,658,276	12/02/2003	Diab et al.	
	178	6,661,161	12/09/2003	Lanzo et al.	
	179	6,668,185	12/23/2003	Toida	
	180	6,671,531	12/30/2003	Al-Ali et al.	
	181	6,678,543	01/13/2004	Diab et al.	
	182	6,681,133	01/20/2004	Chaiken et al.	
	183	6,684,090	01/27/2004	Ali et al.	
	184	6,684,091	01/27/2004	Parker	
	185	6,697,656	02/24/2004	Al-Ali	
	186	6,697,657	02/24/2004	Shehada, et al.	
	187	6,697,658	02/24/2004	Al-Ali	
	188	6,699,194	03/02/2004	Diab et al.	
	189	6,714,804	03/30/2004	Al-Ali et al.	
	190	6,721,582	04/13/2004	Trepagnier, et al.	
	191	6,721,585	04/13/2004	Parker	
	192	6,725,075	04/20/2004	Al-Ali	
	193	6,728,560	04/27/2004	Kollias, et al.	
	194	6,735,459	05/11/2004	Parker	
	195	6,745,060	06/01/2004	Diab et al.	
	196	6,748,254	06/08/2004	O'Neil et al.	
	197	6,760,607	07/06/2004	Al-Ali	
	198	6,770,028	08/03/2004	Ali et al.	
	199	6,771,994	08/03/2004	Kiani et al.	
	200	6,792,300	09/14/2004	Diab et al.	
	201	6,813,511	11/02/2004	Diab et al.	
	202	6,816,010	11/09/2004	Seetharaman et al.	
	203	6,816,241	11/09/2004	Grubisic, et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 8 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	204	6,816,741	11/09/2004	Diab	
	205	6,822,564	11/23/2004	Al-Ali	
	206	6,826,419	11/30/2004	Diab et al.	
	207	6,830,711	12/14/2004	Mills et al.	
	208	6,850,787	02/01/2005	Weber et al.	
	209	6,850,788	02/01/2005	Al-Ali	
	210	6,852,083	02/08/2005	Caro et al.	
	211	6,861,639	03/01/2005	Al-Ali	
	212	6,898,452	05/24/2005	Al-Ali et al.	
	213	6,912,413	06/28/2005	Rantala et al.	
	214	6,920,345	07/19/2005	Al-Ali et al.	
	215	6,931,268	08/16/2005	Kiani-Azarbayjany et al.	
	216	6,934,570	08/23/2005	Kiani et al.	
	217	6,939,305	09/06/2005	Flaherty et al.	
	218	6,943,348	09/13/2005	Coffin IV	
	219	6,950,687	09/27/2005	Al-Ali	
	220	6,961,598	11/01/2005	Diab	
	221	6,970,792	11/29/2005	Diab	
	222	6,979,812	12/27/2005	Al-Ali	
	223	6,985,764	01/10/2006	Mason et al.	
	224	6,993,371	01/31/2006	Kiani et al.	
	225	6,995,400	02/07/2006	Mizuyoshi	
	226	6,996,427	02/07/2006	Ali et al.	
	227	6,999,904	02/14/2006	Weber et al.	
	228	7,003,338	02/21/2006	Weber et al.	
	229	7,003,339	02/21/2006	Diab et al.	
	230	7,015,451	03/21/2006	Dalke et al.	
	231	7,024,233	04/04/2006	Ali et al.	
	232	7,027,849	04/11/2006	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 9 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	233	7,030,749	04/18/2006	Al-Ali	
	234	7,039,449	05/02/2006	Al-Ali	
	235	7,041,060	05/09/2006	Flaherty et al	
	236	7,044,918	05/16/2006	Diab	
	237	7,047,054	05/16/2006	Benni	
	238	7,067,893	06/27/2006	Mills et al.	
	239	7,092,757	08/15/2006	Larson et al.	
	240	7,096,052	08/22/2006	Mason et al.	
	241	7,096,054	08/22/2006	Abdul-Hafiz et al.	
	242	7,132,641	11/07/2006	Schulz et al.	
	243	7,142,901	11/28/2006	Kiani et al.	
	244	7,149,561	12/12/2006	Diab	
	245	7,186,966	03/06/2007	Al-Ali	
	246	7,190,261	03/13/2007	Al-Ali	
	247	7,215,984	05/08/2007	Diab	
	248	7,215,986	05/08/2007	Diab	
	249	7,221,971	05/22/2007	Diab	
	250	7,225,006	05/29/2007	Al-Ali et al.	
	251	7,225,007	05/29/2007	Al-Ali	
	252	7,230,227	06/12/2007	Wilcken et al.	
	253	7,239,905	07/03/2007	Kiani-Azarbayjany et al.	
	254	7,245,953	07/17/2007	Parker	
	255	7,254,429	08/07/2007	Schurman et al.	
	256	7,254,431	08/07/2007	Al-Ali	
	257	7,254,433	08/07/2007	Diab et al.	
	258	7,254,434	08/07/2007	Schulz et al.	
	259	7,272,425	09/18/2007	Al-Ali	
	260	7,274,955	09/25/2007	Kiani et al.	
	261	7,280,858	10/09/2007	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 10 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	262	7,289,835	10/30/2007	Mansfield et al.	
	263	7,292,883	11/06/2007	De Felice et al.	
	264	7,295,866	11/13/2007	Al-Ali	
	265	7,328,053	02/05/2008	Diab et al.	
	266	7,332,784	02/19/2008	Mills, et al.	
	267	7,340,287	03/04/2008	Mason et al.	
	268	7,341,559	03/11/2008	Schulz et al.	
	269	7,343,186	03/11/2008	Lamego et al.	
	270	7,355,512	04/08/2008	Al-Ali	
	271	7,356,365	04/08/2008	Schurman	
	272	7,365,923	04/29/2008	Hargis et al.	
	273	7,371,981	05/13/2008	Abdul-Hafiz	
	274	7,373,193	05/13/2008	Al-Ali et al.	
	275	7,373,194	05/13/2008	Weber et al.	
	276	7,376,453	05/20/2008	Diab et al.	
	277	7,377,794	05/27/2008	Al Ali et al.	
	278	7,377,899	05/27/2008	Weber et al.	
	279	7,383,070	06/03/2008	Diab et al.	
	280	7,395,189	07/01/2008	Qing et al.	
	281	7,415,297	08/19/2008	Al-Ali et al.	
	282	7,428,432	09/23/2008	Ali et al.	
	283	7,438,683	10/21/2008	Al-Ali et al.	
	284	7,440,787	10/21/2008	Diab	
	285	7,454,240	11/18/2008	Diab et al.	
	286	7,467,002	12/16/2008	Weber et al.	
	287	7,469,157	12/23/2008	Diab et al.	
	288	7,471,969	12/30/2008	Diab et al.	
	289	7,471,971	12/30/2008	Diab et al.	
	290	7,483,729	01/27/2009	Al-Ali et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 11 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	291	7,483,730	01/27/2009	Diab et al.	
	292	7,489,958	02/10/2009	Diab et al.	
	293	7,496,391	02/24/2009	Diab et al.	
	294	7,496,393	02/24/2009	Diab et al.	
	295	7,499,741	03/03/2009	Diab et al.	
	296	7,499,835	03/03/2009	Weber et al.	
	297	7,500,950	03/10/2009	Al-Ali et al.	
	298	7,509,153	03/24/2009	Blank et al.	
	299	7,509,154	03/24/2009	Diab et al.	
	300	7,509,494	03/24/2009	Al-Ali	
	301	7,510,849	03/31/2009	Schurman et al.	
	302	7,526,328	04/28/2009	Diab et al.	
	303	7,530,942	05/12/2009	Diab	
	304	7,530,949	05/12/2009	Al Ali et al.	
	305	7,530,955	05/12/2009	Diab et al.	
	306	7,563,110	07/21/2009	Al-Ali et al.	
	307	7,596,398	09/29/2009	Al-Ali et al.	
	308	7,606,606	10/20/2009	Laakkonen	
	309	7,618,375	11/17/2009	Flaherty	
	310	7,647,083	01/12/2010	Al-Ali et al.	
	311	7,657,294	02/02/2010	Eghbal et al.	
	312	7,657,295	02/02/2010	Coakley et al.	
	313	7,657,296	02/02/2010	Raridan et al.	
	314	7,729,733	06/01/2010	Al-Ali et al.	
	315	7,734,320	06/08/2010	Al-Ali	
	316	7,761,127	07/20/2010	Al-Ali et al.	
	317	7,761,128	07/20/2010	Al-Ali et al.	
	318	7,764,982	07/27/2010	Dalke et al.	
	319	7,791,155	09/07/2010	Diab	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

CX-1623

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 12 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	320	7,801,581	09/21/2010	Diab	
	321	7,809,418	10/05/2010	Xu	
	322	7,822,452	10/26/2010	Schurman et al.	
	323	7,844,313	11/30/2010	Kiani et al.	
	324	7,844,314	11/30/2010	Al-Ali	
	325	7,844,315	11/30/2010	Al-Ali	
	326	7,865,222	01/04/2011	Weber et al.	
	327	7,873,497	01/18/2011	Weber et al.	
	328	7,880,606	02/01/2011	Al-Ali	
	329	7,880,626	02/01/2011	Al-Ali et al.	
	330	7,891,355	02/22/2011	Al-Ali et al.	
	331	7,894,868	02/22/2011	Al-Ali et al.	
	332	7,899,506	03/01/2011	Xu et al.	
	333	7,899,507	03/01/2011	Al-Ali et al.	
	334	7,899,518	03/01/2011	Trepagnier et al.	
	335	7,904,132	03/08/2011	Weber et al.	
	336	7,909,772	03/22/2011	Popov et al.	
	337	7,910,875	03/22/2011	Al-Ali	
	338	7,919,713	04/05/2011	Al-Ali et al.	
	339	7,937,128	05/03/2011	Al-Ali	
	340	7,937,129	05/03/2011	Mason et al.	
	341	7,937,130	05/03/2011	Diab et al.	
	342	7,941,199	05/10/2011	Kiani	
	343	7,951,086	05/31/2011	Flaherty et al.	
	344	7,957,780	06/07/2011	Lamego et al.	
	345	7,962,188	06/14/2011	Kiani et al.	
	346	7,962,190	06/14/2011	Diab et al.	
	347	7,976,472	07/12/2011	Kiani	
	348	7,988,637	08/02/2011	Diab	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 13 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	349	7,990,382	08/02/2011	Kiani	
	350	7,991,446	08/02/2011	Al-Ali et al.	
	351	8,000,761	08/16/2011	Al-Ali	
	352	8,008,088	08/08/2011	Bellott et al.	
	353	8,019,400	09/13/2011	Diab et al.	
	354	8,028,701	10/04/2011	Al-Ali et al.	
	355	8,029,765	10/04/2011	Bellott et al.	
	356	8,036,728	10/11/2011	Diab et al.	
	357	8,044,998	10/25/2011	Heenan	
	358	8,046,040	10/25/2011	Ali et al.	
	359	8,046,041	10/25/2011	Diab et al.	
	360	8,046,042	10/25/2011	Diab et al.	
	361	8,048,040	11/01/2011	Kiani	
	362	8,050,728	11/01/2011	Al-Ali et al.	
	363	8,118,620	02/21/2012	Al-Ali et al.	
	364	8,126,528	02/28/2012	Diab et al.	
	365	8,126,531	02/28/2012	Crowley	
	366	8,128,572	03/06/2012	Diab et al.	
	367	8,130,105	03/06/2012	Al-Ali et al.	
	368	8,145,287	03/27/2012	Diab et al.	
	369	8,150,487	04/03/2012	Diab et al.	
	370	8,175,672	05/08/2012	Parker	
	371	8,180,420	05/15/2012	Diab et al.	
	372	8,182,443	05/22/2012	Kiani	
	373	8,185,180	05/22/2012	Diab et al.	
	374	8,190,223	05/29/2012	Al-Ali et al.	
	375	8,190,227	05/29/2012	Diab et al.	
	376	8,203,438	06/19/2012	Kiani et al.	
	377	8,203,704 (CERCA.004A)	06/19/2012	Merritt et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 14 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	378	8,219,170	07/10/2012	Hausmann et al.	
	379	8,224,411	07/17/2012	Al-Ali et al.	
	380	8,228,181	07/24/2012	Al-Ali	
	381	8,229,533	07/24/2012	Diab et al.	
	382	8,233,955	07/31/2012	Al-Ali et al.	
	383	8,244,325	08/14/2012	Al-Ali et al.	
	384	8,255,026	08/28/2012	Al-Ali	
	385	8,255,027	08/28/2012	Al-Ali et al.	
	386	8,255,028	08/28/2012	Al-Ali et al.	
	387	8,260,577	09/04/2012	Weber et al.	
	388	8,265,723	09/11/2012	McHale et al.	
	389	8,274,360	09/25/2012	Sampath et al.	
	390	8,301,217	10/30/2012	Al-Ali et al.	
	391	8,310,336	11/13/2012	Muhsin et al.	
	392	8,315,683	11/20/2012	Al-Ali et al.	
	393	8,332,006	12/11/2012	Naganuma et al.	
	394	8,337,403	12/25/2012	Al-Ali et al.	
	395	8,346,330	01/01/2013	Lamego	
	396	8,353,842	01/15/2013	Al-Ali et al.	
	397	8,355,766	01/15/2013	MacNeish, III et al.	
	398	8,359,080	01/22/2013	Diab et al.	
	399	8,364,223	01/29/2013	Al-Ali et al.	
	400	8,364,226	01/29/2013	Diab et al.	
	401	8,374,665	02/12/2013	Lamego	
	402	8,380,272	02/19/2013	Barrett et al.	
	403	8,385,995	02/26/2013	Al-ali et al.	
	404	8,385,996	02/26/2013	Smith et al.	
	405	8,388,353	03/05/2013	Kiani et al.	
	406	8,399,822	03/19/2013	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 15 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	407	8,401,602	03/19/2013	Kiani	
	408	8,405,608	03/26/2013	Al-Ali et al.	
	409	8,414,499	04/09/2013	Al-Ali et al.	
	410	8,418,524	04/16/2013	Al-Ali	
	411	8,421,022	04/16/2013	Rozenfeld	
	412	8,423,106	04/16/2013	Lamego et al.	
	413	8,428,674	04/23/2013	Duffy et al.	
	414	8,428,967	04/23/2013	Olsen et al.	
	415	8,430,817	04/30/2013	Al-Ali et al.	
	416	8,437,825 (CERCA.007A)	05/07/2013	Dalvi et al.	
	417	8,455,290	06/04/2013	Siskavich	
	418	8,457,703	06/04/2013	Al-Ali	
	419	8,457,707	06/04/2013	Kiani	
	420	8,463,349	06/11/2013	Diab et al.	
	421	8,466,286	06/18/2013	Bellot et al.	
	422	8,471,713	06/25/2013	Poeze et al.	
	423	8,473,020	06/25/2013	Kiani et al.	
	424	8,483,787	07/09/2013	Al-Ali et al.	
	425	8,489,364	07/16/2013	Weber et al.	
	426	8,498,684	07/30/2013	Weber et al.	
	427	8,509,867	08/13/2013	Workman et al.	
	428	8,515,509 (CERCA.005A)	08/20/2013	Bruinsma et al.	
	429	8,523,781	09/03/2013	Al-Ali	
	430	8,529,301	09/10/2013	Al-Ali et al.	
	431	8,532,727	09/10/2013	Ali et al.	
	432	8,532,728	09/10/2013	Diab et al.	
	433	8,547,209	10/01/2013	Kiani et al.	
	434	8,548,548	10/01/2013	Al-Ali	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 16 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	435	8,548,550	10/01/2013	Al-Ali et al.	
	436	8,560,032	10/15/2013	Al-Ali et al.	
	437	8,560,034	10/15/2013	Diab et al.	
	438	8,570,503 (CERCA.004C1)	10/29/2013	Hung Vo	
	439	8,577,431 (CERCA.006A)	11/05/2013	Lamego et al.	
	440	8,584,345	10//2013	Al-Ali et al.	
	441	8,588,880	11//2013	Abdul-Hafiz et al.	
	442	8,600,467	12//2013	Al-Ali et al.	
	443	8,602,971	12/10/2013	Farr	
	444	8,606,342	12//2013	Diab	
	445	8,626,255	01//2014	Al-Ali et al.	
	446	8,630,691 (CERCA.003A)	01/14/2014	Lamego et al.	
	447	8,634,889	01//2014	Al-Ali et al.	
	448	8,641,631	02//2014	Sierra et al.	
	449	8,652,060	02//2014	Al-Ali	
	450	8,663,107	03//2014	Kiani	
	451	8,666,468	03//2014	Al-Ali	
	452	8,667,967	03//2014	Al-Ali et al.	
	453	8,670,811	03//2014	O'Reilly	
	454	8,670,814	03//2014	Diab et al.	
	455	8,676,286	03//2014	Weber et al.	
	456	8,682,407	03//2014	Al-Ali	
	457	8,688,183 (CERCA.008A)	04/01/2014	Bruinsma et al.	
	458	8,690,799	04//2014	Telfort et al.	
	459	8,700,112	04//2014	Kiani	
	460	8,702,627	04//2014	Telfort et al.	
	461	8,706,179	04//2014	Parker	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.



PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 17 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	462	8,712,494	04//2014	MacNeish, III et al.	
	463	8,715,206	05//2014	Telfort et al.	
	464	8,718,735	05//2014	Lamego et al.	
	465	8,718,737	05//2014	Diab et al.	
	466	8,720,249	05//2014	Al-Ali	
	467	8,721,541	05//2014	Al-Ali et al.	
	468	8,721,542	05//2014	Al-Ali et al.	
	469	8,723,677	05//2014	Kiani	
	470	8,740,792	06//2014	Kiani et al.	
	471	8,754,776	06//2014	Poeze et al.	
	472	8,755,535	06//2014	Telfort et al.	
	473	8,755,856	06//2014	Diab et al.	
	474	8,755,872	06//2014	Marinow	
	475	8,761,850	06//2014	Lamego	
	476	8,909,310 (CERCA.003D1)	12/09/2014	Lamego et al.	
	477	9,186,102 (MASCER.008C1)	11/17/2015	Bruinsma et al.	
	478	2002/0099279	07/25/2002	Pfeiffer et al.	
	479	2006/0005944	01/12/2006	Wang et al.	
	480	2006/0025659	02/02/2006	Kiguchi et al.	
	481	2007/0293792	12/20/2007	Sliwa et al.	
	482	2008/0130232	06/05/2008	Yamamoto	
	483	2008/0139908	06/12/2008	Kurth	
	484	2009/0030327	01/29/2009	Chance, Britton	
	485	2009/0043180	02/12/2009	Tschautscher et al.	
	486	2009/0129102	05/21/2009	Xiao et al.	
	487	2009/0259114	10/15/2009	Johnson et al.	
	488	2010/0004518 (011A)	01/07/2010	Vo et al.	
	489	2010/0030040 (CERCA.002A)	02/04/2010	Poeze et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 18 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	490	2011/0004082 (CERCA.002C1)	01/06/2011	Poeze et al.	
	491	2011/0105865	05/05/2011	Yu et al.	
	492	2013/0317370 (CERCA.007C1)	11/28/2013	Dalvi et al.	
	493	2014/0066783 (CERCA.006C1)	03/06/2014	Kiani et al.	
	494	2014/0296664 (CERCA.008C1)	03/27/2014	Bruinsma et al.	
	495	2014/0155712 (CERCA.003D1)	06/05/2014	Lamego et al.	
	496	D326,715	06/02/1992	Schmidt, Michael	
	497	D353,195	12/06/1994	Savage et al.	
	498	D353,196	12/06/1994	Savage et al.	
	499	D356,870	03/28/1995	Ivers et al.	
	500	D359,546	06/20/1995	Savage, et al.	
	501	D361,840	08/29/1995	Savage et al.	
	502	D362,063	09/05/1995	Savage et al.	
	503	D363,120	10/10/1995	Savage et al.	
	504	D378,414	03/11/1997	Allen et al.	
	505	D390,666	02/01/1998	Lagerlof, Ingemar	
	506	D393,830	04/28/1998	Tobler et al.	
	507	D403,070	12/22/1998	Maeda et al.	
	508	D414,870	10/05/1999	Saltzstein et al.	
	509	D452,012	12/11/2001	Phillips, Barney L.	
	510	D455,834	04/16/2002	Donars et al.	
	511	D463,561	09/24/2002	Fukatsu et al.	
	512	D481,459	10/28/2003	Nahm, Werner	
	513	D502,655	03/08/2005	Huang, Chun-Mu	
	514	D508,862	08/30/2005	Behar et al.	
	515	D510,625	10/11/2005	Widener et al.	
	516	D514,461	02/07/2006	Harju, Jonne	
	517	D535,031	01/09/2007	Barrett et al.	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 19 OF 22	Attorney Docket No.	MASCER.002C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	518	D537,164	02/20/2007	Shigemori et al.	
	519	D547,454	07/24/2007	Hsieh, Chin-Chih	
	520	D549,830	08/28/2007	Behar et al.	
	521	D550,364	09/04/2007	Glover et al.	
	522	D551,350	09/18/2007	Lorimer et al.	
	523	D553,248	10/16/2007	Nguyen	
	524	D554,263	10/30/2007	Al-Ali	
	525	D562,985	02/26/2008	Brefka et al.	
	526	D566,282	04/08/2008	Al-Ali et al.	
	527	D567,125	04/22/2008	Okabe et al.	
	528	D569,001	05/13/2008	Omaki	
	529	D569,521	05/20/2008	Omaki	
	530	D587,657	03/03/2009	Al-Ali et al.	
	531	D603,966	11/10/2009	Jones et al.	
	532	D606,659 (010DA)	12/22/2009	Kiani et al.	
	533	D609,193	02/02/2010	Al-Ali et al.	
	534	D614,305	04/20/2010	Al-Ali et al.	
	535	D621,516 (009DA)	08/10/2010	Kiani et al.	
	536	D692,145	10/22/2013	Al-Ali et al.	
	537	RE38,476	03/01/2004	Diab et al.	
	538	RE38,492	04/06/2004	Diab et al.	
	539	RE39,672	06/05/2007	Shehada et al.	
	540	RE41,317	05/04/2010	Parker	
	541	RE41,912	11/02/2010	Parker	
	542	RE42,753	09/27/2011	Kiani-Azarbayjany et al.	
	543	RE43,169	02/07/2012	Parker	
	544	RE43,860	12/11/2012	Parker	
	545	RE44,823	04/2014	Parker	

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>  <i>(Multiple sheets used when necessary)</i>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
	Examiner	Unknown
SHEET 20 OF 22	Attorney Docket No.	MASCER.002C2

## U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number Number - Kind Code (if known) Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	546	RE44,875	04/2014	Kiani et al.	

## FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document Country Code-Number-Kind Code Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T <sup>1</sup>
	547	EP 419223	03/27/1991	Minnesota Mining and Manufacturing Company		
	548	JP 5756752 (MASCER.007JP)	06/05/2015	MASIMO LABORATORIES, INC.		
	549	JP 2002-500908 A	01/15/2002	Lightouch Medical Inc.		Abs
	550	JP 2007-389463 A	11/08/2007	Konica Minolta Sensing Inc.		Abs
	551	JP 2003-265444 A	09/24/2003	Shimadzu Corp.		Abs
	552	JP 06-327658 A /app JP 08-185864 /pub	07/16/1996	Matsushita Electric Ind Co Ltd		Abs
	553	JP 11-244266 /app JP 2001-66990 /pub	03/16/2001	Sumitomo Bakelite Co Ltd		Abs
	554	JP 04-158843 / app JP 05-325705 A / pub	12/10/1993	Fuji Porimatetsuku KK		Abs
	555	JP 2001-087250 A	04/03/2001	Cas Medical Systems Inc.		Abs
	556	JP 2006-177837 A	07/06/2006	Hitachi Ltd.		Abs
	557	JP 2003-024276 A	01/28/2003	Pentax Corp.		Abs
	558	JP 2008-099222 A	04/24/2008	Konica Minolta Holdings Inc.		Abs
	559	JP 2006-198321 A	08/03/2006	Hitachi Ltd.		Abs
	560	JP 2003-508104 A	03/04/2003	Quantum Vision Inc.		Abs
	561	WO 1993/12712	07/08/1993	Vivascan Corp		
	562	WO 1999/000053	01/07/1999	TOA Medical Electronics		
	563	WO 2000/25112	05/04/2000	Rolfe		
	564	WO 2014/149781 (CERCA.082WO)	09/25/2014	Cercacor Laboratories, Inc.		
	565	WO 2014/158820 (CERCA.067WO)	10/02/2014	Cercacor Laboratories, Inc.		
	566	WO 1999/01704	07/29/1999	General Electric Company		

## NON PATENT LITERATURE DOCUMENTS

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 21 OF 22	Attorney Docket No.	MASCER.002C2

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	567	PCT International Search Report, App. No. PCT/US2010/047899, Date of Actual Completion of Search: 01/26/2011, 4 pages.	
	568	International Search Report and Written Opinion for PCT/US2009/049638, mailed January 7, 2010.	
	569	International Search Report issued in Application No. PCT/US2009/052756, mailed February 10, 2009 in 14 pages.	
	570	International Preliminary Report on Patentability and Written Opinion of the International Searching Authority issued in Application No. PCT US2009/049638, mailed January 5, 2011 in 9 pages.	
	571	International Preliminary Report on Patentability and Written Opinion of the International Searching Authority issued in Application No. PCT/US2009/052756, mailed February 8, 2011 in 8 pages.	
	572	Burritt, Mary F.; Current Analytical Approaches to Measuring Blood Analytes; Vol. 36; No. 8(B); 1990	
	573	Hall, et al., Jeffrey W.; Near-Infrared Spectrophotometry: A New Dimension in Clinical Chemistry; Vol. 38; No. 9; 1992	
	574	Kuenstner, et al., J. Todd; Measurement of Hemoglobin in Unlysed Blood by Near-Infrared Spectroscopy; Vol. 48; Number 4, 1994	
	575	Manzke, et al., B., Multi Wavelength Pulse Oximetry in the Measurement of Hemoglobin Fractions; SPIE, Vol. 2676, April 24, 1996	
	576	Naumenko, E. K.; Choice of Wavelengths for Stable Determination of Concentrations of Hemoglobin Derivatives from Absorption Spectra of Erythrocytes; Vol. 63; No. 1; pp. 60-66 January – February 1996; Original article submitted November 3, 1994	
	577	Schmitt, Joseph M.; Simple Photon Diffusion Analysis of the Effects of Multiple Scattering on Pulse Oximetry; March 14, 1991; revised August 30, 1991	
	578	Schmitt, et al., Joseph M.; Measurement of Blood Hematocrit by Dual-Wavelength near-IR Photoplethysmography; Vol. 1641; 1992	
	579	Schnapp, et al., L.M.; Pulse Oximetry. Uses and Abuses.; Chest 1990; 98; 1244-1250 DOI 10.1378/Chest.98.5.1244	
	580	<a href="http://www.masimo.com/rainbow/pronto.htm">http://www.masimo.com/rainbow/pronto.htm</a> Noninvasive & Immediate Hemoglobin Testing, printed on August 20, 2009	
	581	<a href="http://www.masimo.com/pulseOximeter/Rad5.htm">http://www.masimo.com/pulseOximeter/Rad5.htm</a> ; Signal Extraction Pulse Oximeter, printed on August 20, 2009	
	582	<a href="http://blogderoliveira.blogspot.com/2008_02_01_archive.html">http://blogderoliveira.blogspot.com/2008_02_01_archive.html</a> ; Ricardo Oliveira, printed on August 20, 2009	
	583	<a href="http://www.masimo.com/rad-57/">http://www.masimo.com/rad-57/</a> ; Noninvasive Measurement of Methemoglobin, Carboxyhemoglobin and Oxyhemoglobin in the blood. Printed on August 20, 2009	
	584	<a href="http://amivital.ugr.es/blog/?tag=spo2">http://amivital.ugr.es/blog/?tag=spo2</a> ; Monitorizacion de la hemoglobina...y mucho mas, printed on August 20, 2009	
	585	<a href="http://www.masimo.com/spco/">http://www.masimo.com/spco/</a> ; Carboxyhemoglobin Noninvasive > Continuous > Immediate, printed on August 20, 2009	

Examiner Signature	Date Considered
<p><b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.</p>	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b>	Application No.	Unknown
	Filing Date	Herewith
	First Named Inventor	Jeroen Poeze
	Art Unit	Unknown
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 22 OF 22	Attorney Docket No.	MASCER.002C2

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>1</sup>
	586	http://www.masimo.com/PARTNERS/WELCHALLYN.htm; Welch Allyn Expands Patient Monitor Capabilities with Masimo Pulse Oximetry Technology, printed on August 20, 2009	
	587	http://www.masimo.com/pulseOximeter/PPO.htm; Masimo Personal Pulse Oximeter, printed on August 20, 2009	
	588	http://www.masimo.com/generalFloor/system.htm; Masimo Patient SafetyNet System at a Glance, printed on August 20, 2009	
	589	http://www.masimo.com/partners/GRASEBY.htm; Graseby Medical Limited, printed on August 20, 2009	
	590	Japanese Office Action, re JP Application No. 2011-516895, mailed September 2, 2014, with translation. (CERCA.007JP).	
	591	Japanese Notice of Allowance, re JP Application No. 2011-516895, issued on May 12, 2015, no translation. (CERCA/MASCER.007JP).	
	592	European Office Action issued in application no. 10763901.5 on 01/11/2013. (CERCA.008EP).	
	593	European Office Action issued in application no. 10763901.5 on 08/27/2014. (CERCA.008EP).	
	594	European Office Action issued in application no. 10763901.5 on 08/06/2015. (CERCA.008EP).	
	595	KANUKURTHY et al., "Data Acquisition Unit for an Implantable Multi-Channel Optical Glucose Sensor", Electro/Information Technology Conference, Chicago, IL, USA, May 17-20, 2007, pp. 1-6	
	596	SMITH, "The Pursuit of Noninvasive Glucose: 'Hunting the Deceitful Turkey'", 2006	
	597	SMALL et al., "Data Handling Issues for Near-Infrared Glucose Measurements", http://www.ieee.org/organizations/pubs/newsletters/leos/apr98/datahandling.htm, accessed 11/27/2007	

22330084

Examiner Signature	Date Considered
<b>*Examiner:</b> Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T<sup>1</sup> - Place a check mark in this area when an English language Translation is attached.

Docket No.: MASCER.002C2

December 28, 2015

App. No.: Unknown

Page 1 of 1

Please Direct All Correspondence to Customer Number 64735

---

**RESCISSION OF ANY PRIOR DISCLAIMERS AND REQUEST TO REVISIT ART**

Inventor	:	Jeroen Poeze
App. No.	:	Unknown
Filed	:	Herewith
For	:	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
Examiner	:	Unknown
Art Unit	:	Unknown
Conf. No.	:	Unknown

---

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

The claims of the present application are different and possibly broader in scope than the claims pursued in the parent application(s). To the extent any prior amendments or characterizations of the scope of any claim or referenced art could be construed as a disclaimer of any subject matter supported by the present disclosure, Applicant hereby rescinds and retracts such disclaimer. Accordingly, the references previously considered in the parent application(s) may need to be re-visited.

Knobbe, Martens, Olson & Bear, LLP

Respectfully submitted,

Dated: December 28, 2015

/Scott Cromar/\_\_\_\_\_  
Scott A. Cromar  
Registration No. 65,066  
Attorney of Record  
Customer No. 64735  
(949) 760-0404

22352416

CX-1623

Electronic Acknowledgement Receipt	
<b>EFS ID:</b>	24460562
<b>Application Number:</b>	14981290
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9573
<b>Title of Invention:</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS
<b>First Named Inventor/Applicant Name:</b>	Jeroen Poeze
<b>Customer Number:</b>	64735
<b>Filer:</b>	Scott Cromar/Kealani Aguon
<b>Filer Authorized By:</b>	Scott Cromar
<b>Attorney Docket Number:</b>	MASCER.002C2
<b>Receipt Date:</b>	28-DEC-2015
<b>Filing Date:</b>	
<b>Time Stamp:</b>	17:17:53
<b>Application Type:</b>	Utility under 35 USC 111(a)

**Payment information:**

Submitted with Payment	no
------------------------	----

**File Listing:**

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ADS_MASCER-002C2.pdf	1824791 69e48d62c83d91cdc0c1341b3e75ca7b010d8963	no	13

**Warnings:****Information:**



CX-1623

2		SPEC_MASCER-002C2.pdf	352831 812c604698cdc196eb58b146cd5f05323f90d085	yes	76
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	74	
	Claims		75	75	
	Abstract		76	76	
Warnings:					
Information:					
3	Drawings-only black and white line drawings	DRW_MASCER-002C2.PDF	1408561 a8a858ebcd373015b7007b4faf3040dca1a939e0	no	65
Warnings:					
Information:					
4	Power of Attorney	POA_MASCER-002C2.pdf	582371 0ab44e6cdfc850cd7ccf625078010674223d888e	no	2
Warnings:					
Information:					
5		IDS_MASCER-002C2.pdf	215619 a55fa030309b8a0a7e2e149c0380eb6ecd4cf0b6	yes	24
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Transmittal Letter		1	2	
	Information Disclosure Statement (IDS) Form (SB08)		3	24	
Warnings:					
Information:					
6	Miscellaneous Incoming Letter	RESC_MASCER-002C2.pdf	15969 3d8f4ccc07944b47f31ac543639903be3b46febe	no	1
Warnings:					
Information:					
Total Files Size (in bytes):			4400142		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		<b>Attorney Docket Number</b>	MASCER.002C2
		<b>Application Number</b>	
<b>Title of Invention</b>	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
<p>The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.</p> <p>This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.</p>			

**Secrecy Order 37 CFR 5.2:**

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

**Inventor Information:**

<b>Inventor</b>	1				<a href="#">Remove</a>	
<b>Legal Name</b>						
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>		
	Jeroen		Poeze			
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service						
<b>City</b>	Rancho Santa Margarita	<b>State/Province</b>	CA	<b>Country of Residence</b>	US	
<b>Mailing Address of Inventor:</b>						
<b>Address 1</b>	63 Tierra Seguro					
<b>Address 2</b>						
<b>City</b>	Rancho Santa Margarita	<b>State/Province</b>	CA			
<b>Postal Code</b>	92688	<b>Country</b>	US			
<b>Inventor</b>	2				<a href="#">Remove</a>	
<b>Legal Name</b>						
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>		
	Marcelo		Lamego			
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service						
<b>City</b>	Cupertino	<b>State/Province</b>	CA	<b>Country of Residence</b>	US	
<b>Mailing Address of Inventor:</b>						
<b>Address 1</b>	10292 Orange Avenue					
<b>Address 2</b>						
<b>City</b>	Cupertino	<b>State/Province</b>	CA			
<b>Postal Code</b>	95014	<b>Country</b>	US			
<b>Inventor</b>	3				<a href="#">Remove</a>	
<b>Legal Name</b>						
<b>Prefix</b>	<b>Given Name</b>	<b>Middle Name</b>	<b>Family Name</b>	<b>Suffix</b>		
	Sean		Merritt			
<b>Residence Information (Select One)</b> <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service						

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number		MASCER.002C2	
		Application Number			
Title of Invention		MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS			

City	Lake Forest	State/Province	CA	Country of Residence	US
------	-------------	----------------	----	----------------------	----

  
**Mailing Address of Inventor:**

Address 1		25111 Paseo Arboleda			
Address 2					
City	Lake Forest	State/Province	CA		
Postal Code	92630	Country i	US		
Inventor	4	<a href="#">Remove</a>			
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Cristiano		Dalvi		
Residence Information (Select One) <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Lake Forest	State/Province	CA	Country of Residence	US

  
**Mailing Address of Inventor:**

Address 1		23972 Oswego St.			
Address 2					
City	Lake Forest	State/Province	CA		
Postal Code	92630	Country i	US		
Inventor	5	<a href="#">Remove</a>			
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Hung		Vo		
Residence Information (Select One) <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Fountain Valley	State/Province	CA	Country of Residence	US

  
**Mailing Address of Inventor:**

Address 1		18849 Teton Cir.			
Address 2					
City	Fountain Valley	State/Province	CA		
Postal Code	92708	Country i	US		
Inventor	6	<a href="#">Remove</a>			
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Johannes		Bruinsma		
Residence Information (Select One) <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

City	Opeinde	Country of Residence <sup>i</sup>	NL
------	---------	-----------------------------------	----

**Mailing Address of Inventor:**

Address 1	Teije Blauwsingel 45		
Address 2			
City	9218 RT Opeinde	State/Province	
Postal Code		Country <sup>i</sup>	NL
Inventor	7	<button>Remove</button>	

**Legal Name**

Prefix	Given Name	Middle Name	Family Name	Suffix
	Ferdyan		Lesmana	

Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service

City	Irvine	State/Province	CA	Country of Residence <sup>i</sup>	US
------	--------	----------------	----	-----------------------------------	----

**Mailing Address of Inventor:**

Address 1	42 New Season		
Address 2			
City	Irvine	State/Province	CA
Postal Code	92602	Country <sup>i</sup>	US
Inventor	8	<button>Remove</button>	

**Legal Name**

Prefix	Given Name	Middle Name	Family Name	Suffix
	Massi	Joe E.	Kiani	

Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service

City	Laguna Niguel	State/Province	CA	Country of Residence <sup>i</sup>	US
------	---------------	----------------	----	-----------------------------------	----

**Mailing Address of Inventor:**

Address 1	1 Point Catalina		
Address 2			
City	Laguna Niguel	State/Province	CA
Postal Code	92677	Country <sup>i</sup>	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.Add**Correspondence Information:**Enter either Customer Number or complete the Correspondence Information section below.  
For further information see 37 CFR 1.33(a).

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

☐ An Address is being provided for the correspondence information of this application.

Customer Number	64735		
Email Address	efiling@knobbe.com	<input type="button" value="Add Email"/>	<input type="button" value="Remove Email"/>

**Application Information:**

Title of the Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		
Attorney Docket Number	MASCER.002C2	Small Entity Status Claimed	<input type="checkbox"/>
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	65	Suggested Figure for Publication (if any)	

**Filing By Reference:**

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

**Publication Information:**
☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

**Representative Information:**

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	<input checked="" type="radio"/> Customer Number	<input type="radio"/> US Patent Practitioner	<input type="radio"/> Limited Recognition (37 CFR 11.9)
Customer Number	64735		

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

**Domestic Benefit/National Stage Information:**

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove		
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
	Continuation of	12/829352	2010-07-01		
Prior Application Status	Abandoned		Remove		
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/829352	Continuation of	12/534827	2009-08-03		
Prior Application Status	Expired		Remove		
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/086060	2008-08-04		
Prior Application Status	Expired		Remove		
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/086108	2008-08-04		
Prior Application Status	Expired		Remove		
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/086063	2008-08-04		
Prior Application Status	Expired		Remove		
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/086057	2008-08-04		
Prior Application Status	Expired		Remove		
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/534827	Claims benefit of provisional	61/091732	2008-08-25		
Prior Application Status	Patented		Remove		
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/829352	Continuation of	12/497528	2009-07-02	8577431	2013-11-03

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

Prior Application Status	Expired	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/086060	2008-08-04		
Prior Application Status	Expired	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/086108	2008-08-04		
Prior Application Status	Expired	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/086063	2008-08-04		
Prior Application Status	Expired	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/086057	2008-08-04		
Prior Application Status	Expired	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/078228	2008-07-03		
Prior Application Status	Expired	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/078207	2008-07-03		
Prior Application Status	Expired	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
12/497528	Claims benefit of provisional	61/091732	2008-08-25		
Prior Application Status	Patented	Remove			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/497528	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10
Prior Application Status	Patented	Remove			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/497528	Continuation in part of	29/323408	2008-08-25	D606659	2009-12-22



Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

Prior Application Status		Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/829352	Continuation of	12/497523	2009-07-02	8437825	2013-05-07
Prior Application Status		Expired			Remove
Application Number		Continuity Type		Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12/497523		Claims benefit of provisional		61/086060	2008-08-04
Prior Application Status		Expired			Remove
Application Number		Continuity Type		Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12/497523		Claims benefit of provisional		61/086108	2008-08-04
Prior Application Status		Expired			Remove
Application Number		Continuity Type		Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12/497523		Claims benefit of provisional		61/086063	2008-08-04
Prior Application Status		Expired			Remove
Application Number		Continuity Type		Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12/497523		Claims benefit of provisional		61/086057	2008-08-04
Prior Application Status					Remove
Application Number		Continuity Type		Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12/497523		Claims benefit of provisional		61/078228	2008-07-03
Prior Application Status		Expired			Remove
Application Number		Continuity Type		Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12/497523		Claims benefit of provisional		61/078207	2008-07-03
Prior Application Status		Expired			Remove
Application Number		Continuity Type		Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12/497523		Claims benefit of provisional		61/091732	2008-08-25
Prior Application Status		Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/497523	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number		MASCER.002C2	
		Application Number			
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS				
Prior Application Status		Patented		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/497523	Continuation in part of	29/323409	2008-08-25	D621516	2010-08-10
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the <b>Add</b> button.					Add

## Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)<sup>i</sup> the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

			Remove
Application Number	Country <sup>i</sup>	Filing Date (YYYY-MM-DD)	Access Code <sup>i</sup> (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the <b>Add</b> button.			Add

## Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

## Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

**NOTE:** This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

### 1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

**A. Priority Document Exchange (PDX)** - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

**B. Search Results from U.S. Application to EPO** - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

### 2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

**NOTE:** Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

**Applicant Information:**

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.			
<b>Applicant</b> 1		<input type="button" value="Remove"/>	
<p>If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.</p>			
<input type="button" value="Clear"/>			
<input type="radio"/> Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor	
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest	
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:			
<div style="border: 1px solid black; height: 20px; width: 100%;"></div>			
Name of the Deceased or Legally Incapacitated Inventor: <div style="border: 1px solid black; width: 400px; height: 20px;"></div>			
If the Applicant is an Organization check here. <input checked="" type="checkbox"/>			
Organization Name	MASIMO CORPORATION		
<b>Mailing Address Information For Applicant:</b>			
Address 1	52 Discovery		
Address 2			
City	Irvine	State/Province	CA
Country	US	Postal Code	92618
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button. <input type="button" value="Add"/>			

**Assignee Information including Non-Applicant Assignee Information:**

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	MASCER.002C2
		Application Number	
Title of Invention	MULTI-STREAM DATA COLLECTION SYSTEM FOR NONINVASIVE MEASUREMENT OF BLOOD CONSTITUENTS		

<b>Assignee</b>   1				
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
<input type="button" value="Remove"/>				
If the Assignee or Non-Applicant Assignee is an Organization check here. <input type="checkbox"/>				
Prefix	Given Name	Middle Name	Family Name	Suffix
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<b>Mailing Address Information For Assignee including Non-Applicant Assignee:</b>				
Address 1		<input type="text"/>		
Address 2		<input type="text"/>		
City	<input type="text"/>	State/Province	<input type="text"/>	
Country i	<input type="text"/>	Postal Code	<input type="text"/>	
Phone Number	<input type="text"/>	Fax Number	<input type="text"/>	
Email Address	<input type="text"/>			
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. <input type="button" value="Add"/>				

**Signature:**

**NOTE:** This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

<b>Signature</b>	/Scott Cromar/		Date (YYYY-MM-DD)	2015-12-28
First Name	Scott	Last Name	Cromar	Registration Number
				65066
Additional Signature may be generated within this form by selecting the Add button. <input type="button" value="Add"/>				